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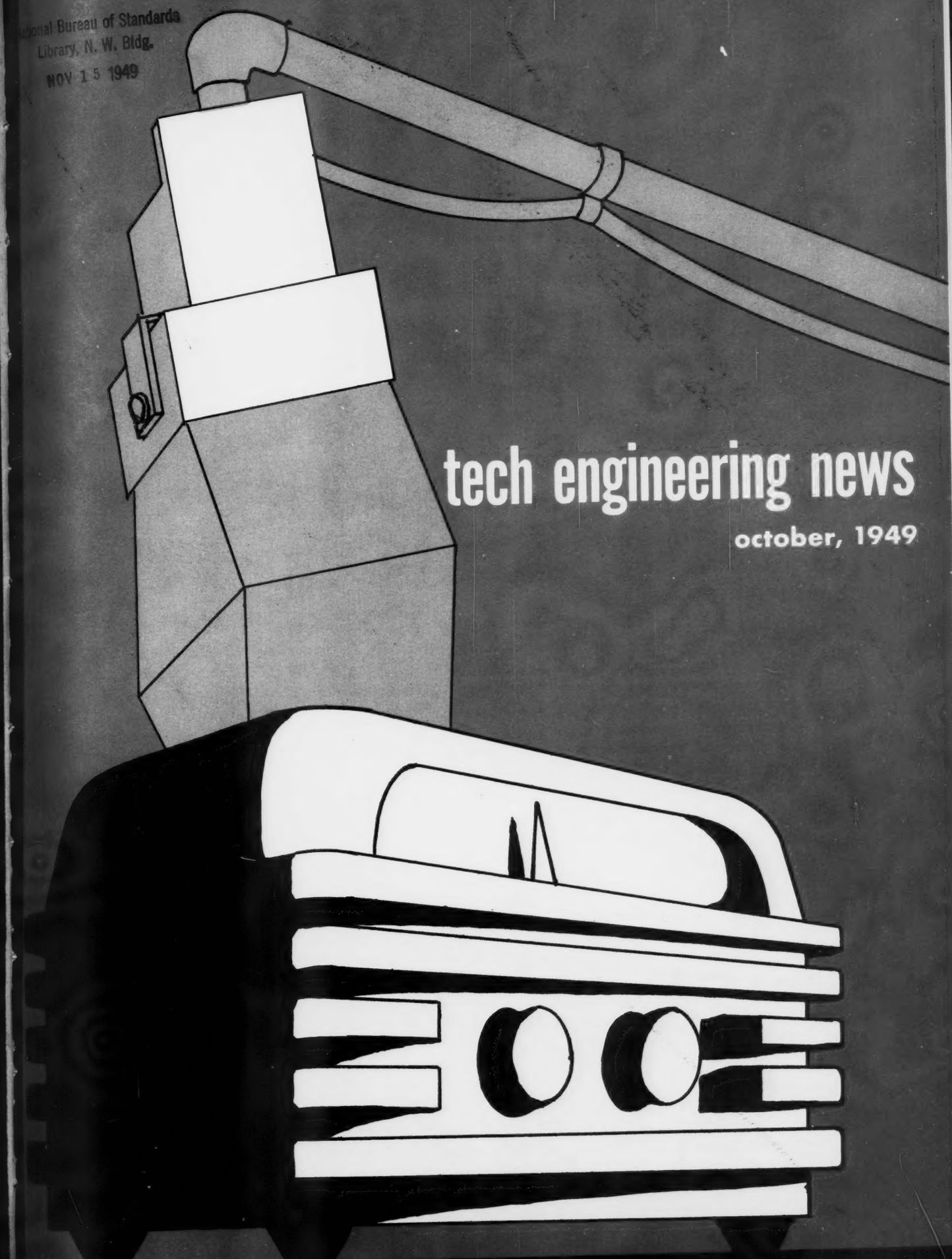
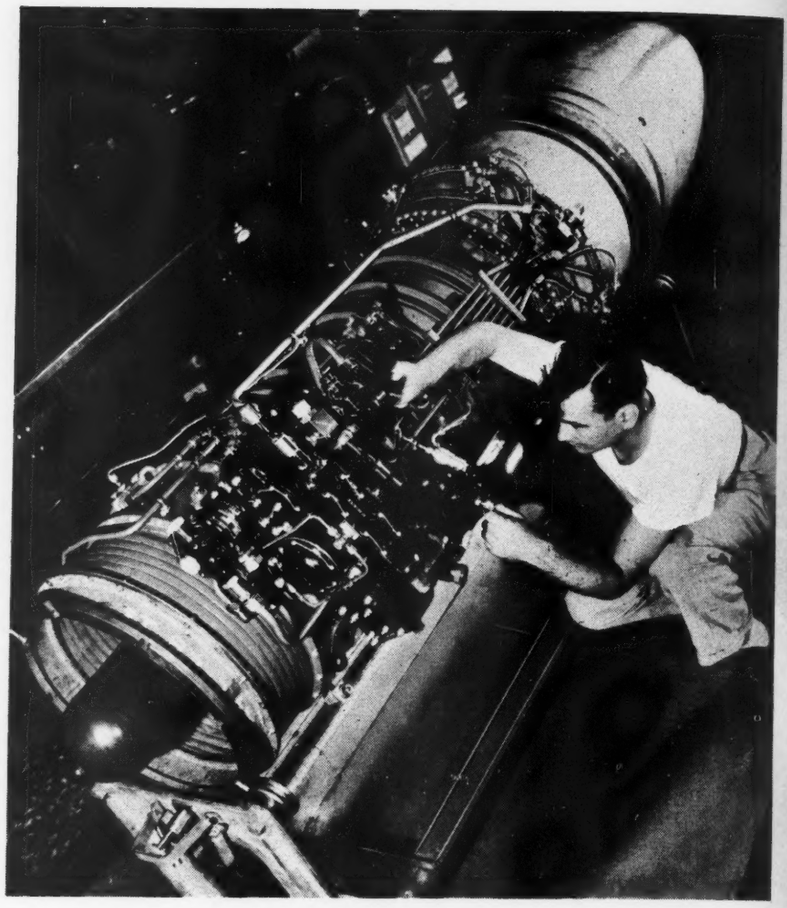


tech engineering news

october, 1949

How many Dimensions has a Name?



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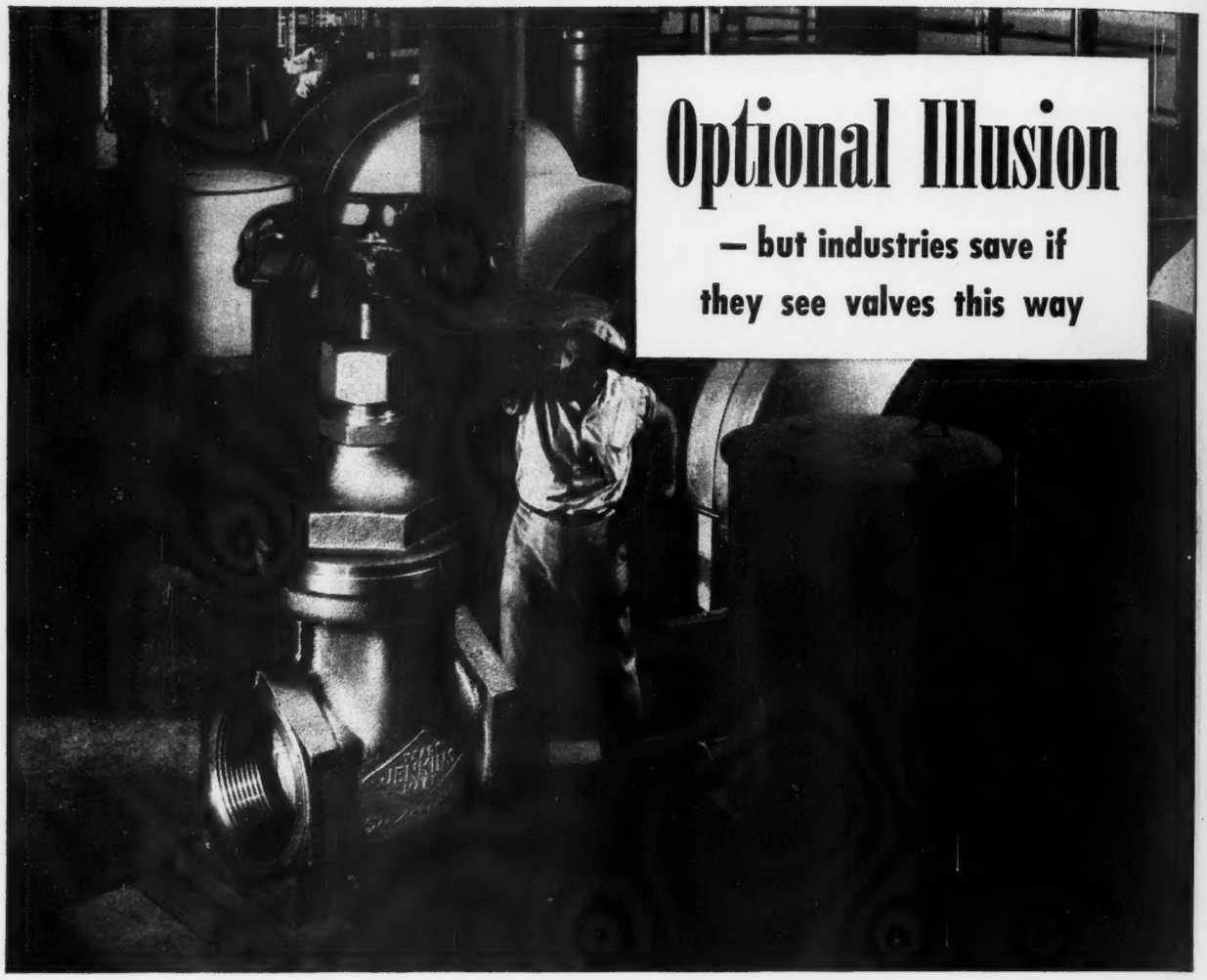

THERE ARE TWO WAYS of regarding the valves in any plant. Management can think of the relatively small cost of a single valve, and dismiss it as a minor, "petty cash" investment. Or, they can think of *all* valves in the plant as *one* valve, as pictured, by photo-magic, in this pharmaceutical plant,—and see valves in proper perspective.

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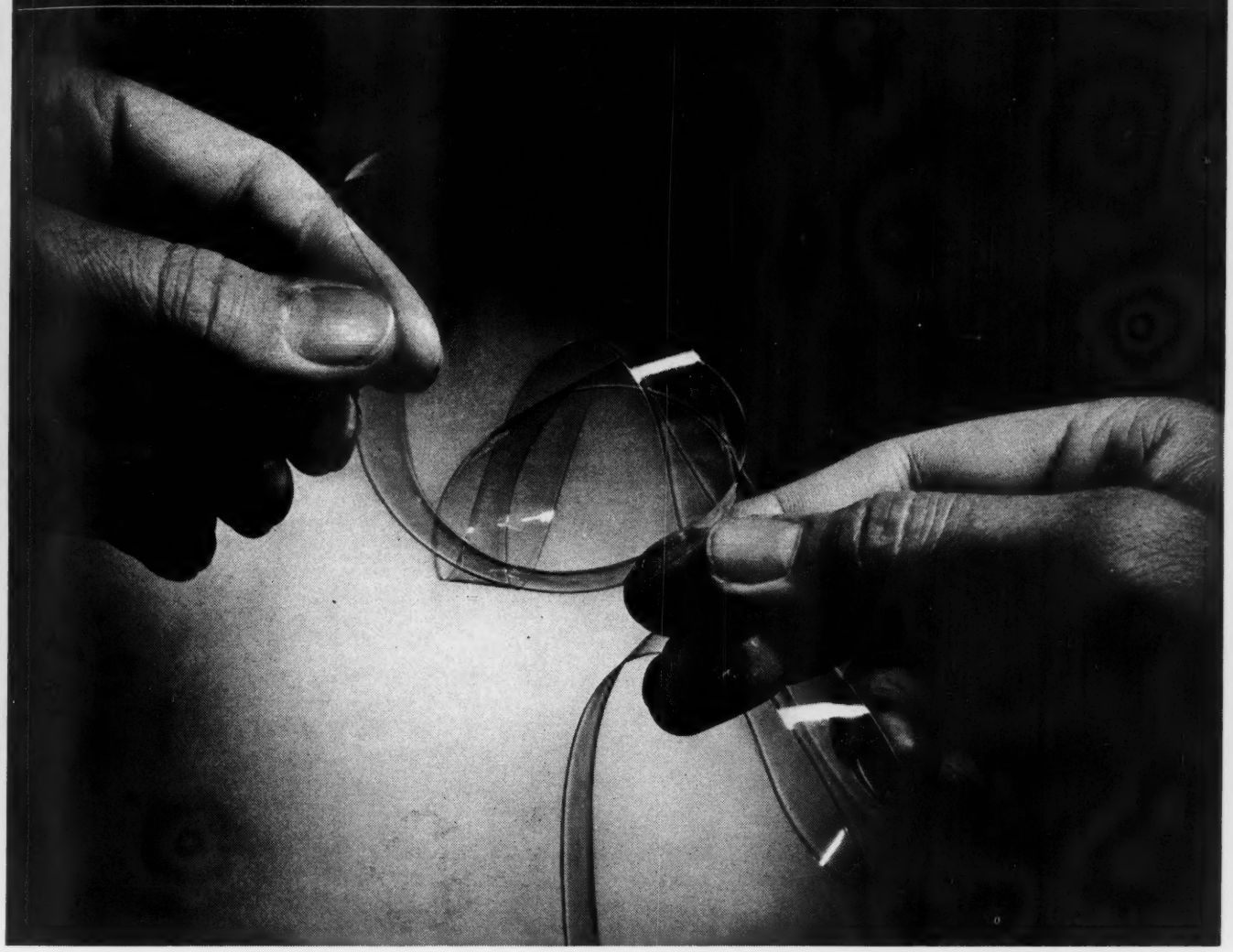

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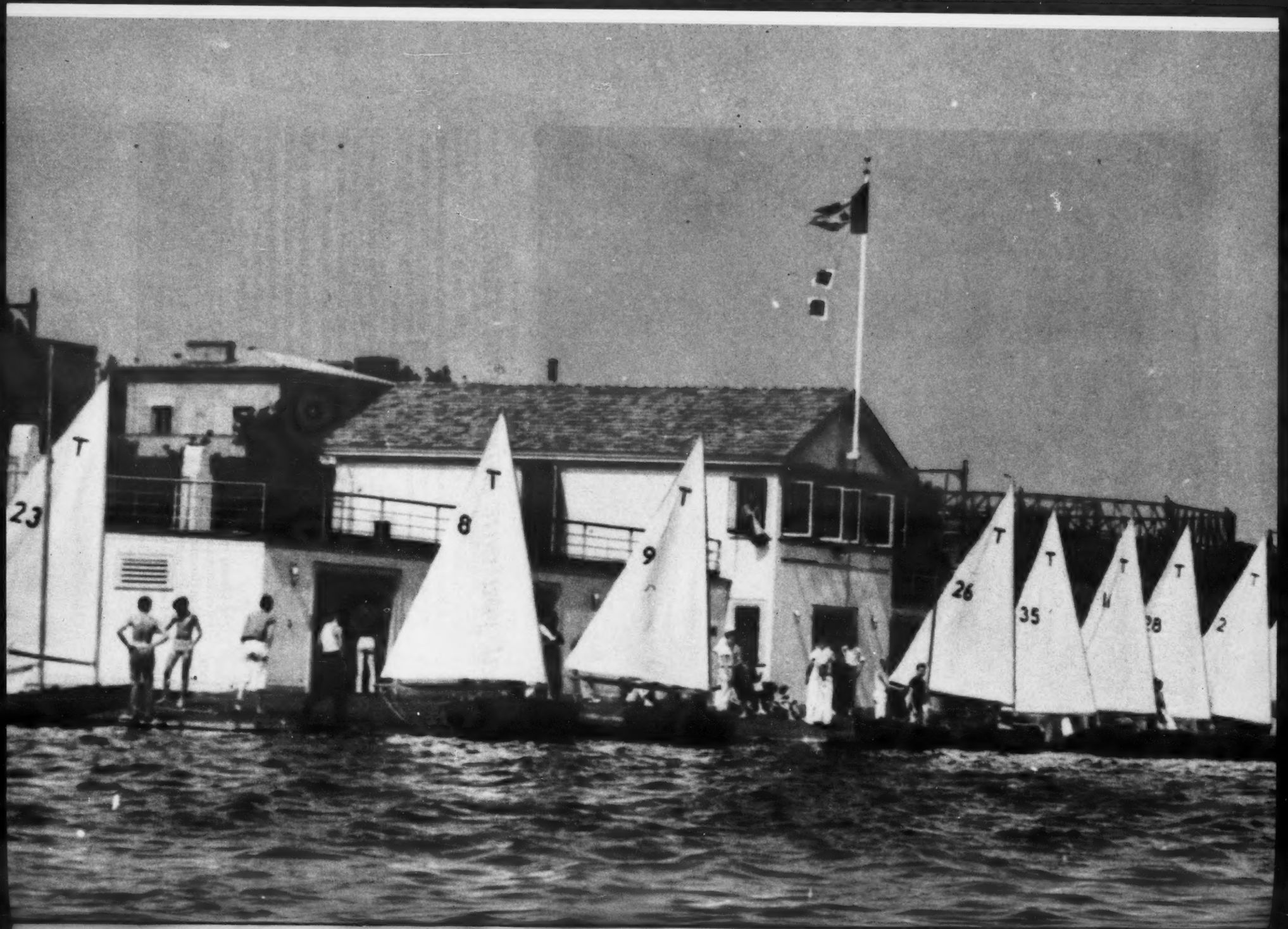
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music on the power lines

WMIT Grows Up

By WMIT Staff

Campus radio station WMIT was started about three years ago by a group of men armed with technical skill and the knowledge that a station was desired by the students. The original equipment was financed by the charter members, aided by a grant of fifty dollars from the Dormitory Committee. By converting a former kitchen and dining room to a control room and studio, WMIT began broadcasting activities on November 29, 1946. With an expanded staff of twenty, the station operated four hours a night, three nights a week, broadcasting to the permanent dormitories.

Early programs were almost entirely music, based on records begged and borrowed from staff members. Since that time, the station has come a long way. A collection of some seven hundred records has been built up, mainly through advertising revenue and new releases from the dealers. A concerted effort has been made to bring the programs as close to commercial standards as possible. In addition to a greater variety of musical programs adapted to the listeners' desires through listener polls, new program schedules include news programs, and programs of special interest to students, such as the interviews with faculty members and campus personalities, reports from the administration, a special program for music appreciation students and the Here's to Veterans show.

In the course of all this, WMIT's staff has grown from an original five members to its present strength of one hundred and five, giving the station the distinction of being the fastest growing activity on the campus.

When a man joins the station staff, he is automatically made a member of the general staff and is put through a training course appropriate to his job on the station. In addition to the usual "on the job" training, special training courses are maintained by the announcing and studio engineering staffs. Practice sessions are held for the announcers, simulating actual operating conditions, both for the purpose of training new announcers and for the ironing out of any awkward or undesirable announcing techniques that may develop after an announcer has been on the job for some time. A tape recorder is on loan from the electrical engineering department for the purpose of recording actual broadcasts of the announcers and playing back during training sessions. This has been found to be the most effective way of pointing out to the men just how they may improve their techniques.

The engineering department maintains a system of classes in which the experienced controlmen take small groups of new men and carefully go over the proper operation and timing of the mechanics of putting the programs on the air. Here again, practice sessions that simulate operating conditions are used extensively. After successfully completing the training course, the new controlman is given a regular shift, with some experienced person present to watch, until the new man is judged capable of handling anything unusual that may occur.

Although the major function of the station is to provide programs of good quality to its listeners, the best of program material is useless without high-quality equipment to transmit it to the listeners. In order to appreciate the present condition of WMIT's technical equipment, it is necessary to consider briefly the equipment used in past years and to see just how the present equipment compares with that of other college carrier current stations and with commercial practice. Before this comparison is made, however, it would be well to explain briefly just how the programs are conveyed from the transmitter to the receiving sets within the service area.

The transmitter is not coupled directly to an antenna as in commercial stations, but is fed into the power lines of the buildings that are to receive the programs. Since radio frequencies will not pass through power distribu-

In 1948 WMIT made a complete equipment change over involving a summer's work by many of the station members.

Among the guests who have presented views over WMIT'S airwaves are President Killian and Dean Baker.

tion transformers, this limits the service area to the buildings fed by direct lines. With this type of transmission, and so long as the signals do not radiate more than a set amount from the lines and distribution system, the station is free of major regulation by the Federal Communications Commission, and is not required to have a station license. Of course, the limitation on the service area imposed by the inability of signals to pass through transformers limits transmission to the buildings to which it is possible to run cables. This is why it is impossible for students living off the campus to hear our programs. A possible solution to this problem would be to lease telephone lines to the fraternities and place small transmitters there.

When the station was first opened in 1946, the equipment was completely homemade, with the before mentioned financial limitation. Consequently, anything approaching what the station would have liked to have had was out of the question. The equipment that was built was sufficient for the needs then, but later developments showed that, as opportunities were presented that would allow remote programs from various points within the Institute, the equipment was not adequate for an expanding station.

Conditions and ambitions finally reached the point where it was absolutely necessary for the station to have new and more modern equipment. A limit was set on expenditures, making it necessary to investigate carefully just what equipment would give the most for the money, and still allow for future expansion. After careful consideration, it was decided that the best way to re-equip would be for the members to build the new material themselves, using quality components, and designing it to suit the needs of WMIT, rather than purchasing one of the various commercial packaged control consoles, even though it would cost more per studio. The present equipment is the result. The station feels that it is entirely adequate for its needs, yet more than versatile enough to meet any new situation or the addition of new studios as the station expands. The control console built cost approximately twice as much as a commercial packaged one would have. At first glance this may not seem to be the more economical thing to have done, but the packaged consoles lack the easy servicing facilities and the extreme flexibility possible in a custom designed console. A commercial console with this flexibility would have cost approximately ten times as much as it did to have station personnel design and build it.

The equipment not in use provides for two-program microphone channels, one announce microphone, remote broadcasts, and any number of turntables, in either the studio or the control room. The master control plans include provision for additional studios, and switching facilities for a network of other stations, using leased telephone lines.

The possibility of putting a low power F.M. transmitter on the air at some future date, made it desirable to have the audio system high-fidelity throughout. This is achieved by the use of the best components available — Linear Standard transformers, Western Electric tubes and techniques, and high quality program faders, or volume controls. The patch panel is the major advantage of our equipment over most packaged consoles, in that it is possible to substitute units and, in effect, rewire the console to fit any special situation, such as the addition of an echo chamber or the play back of a program previously recorded on tape or wire. The program of designing each console to fit the needs of that studio, rather than using a standard console, as most other

(*Continued on page 26*)

from coal to coke

By John W. Wright, '51

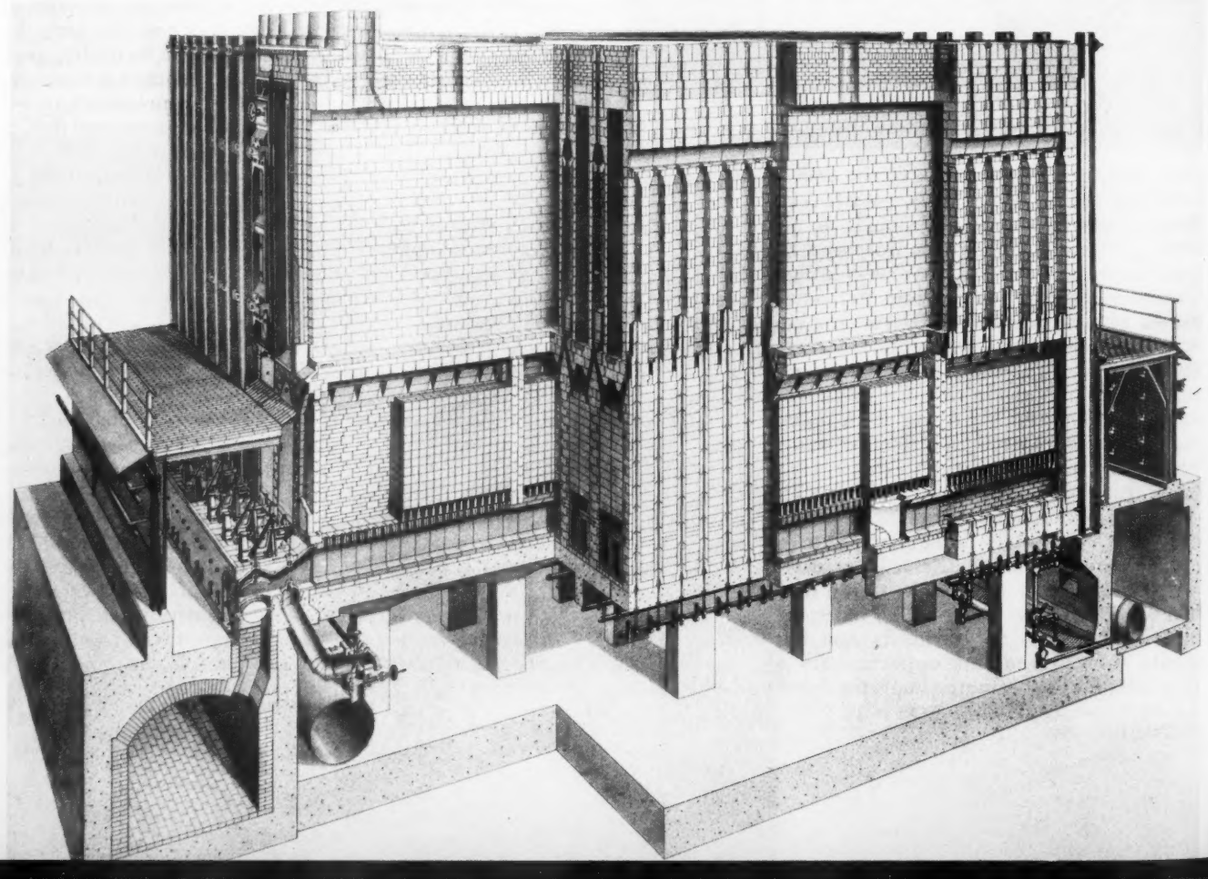
Many impressive and economically important structures in today's heavy industry are of refractory brick construction. Blast furnaces and other non-ferrous refinery ovens are of this type, but one of the most important and little known is the "by-product" coke oven.

Functionally, a coke oven plant is designed for the production of metallurgical coke, fuel gas, or basic coal tar chemicals. The by-product coke oven makes possible the fulfillment of all three functions, and the name combination oven is often applied to it. At present, there are also in operation "gas retorts," in which the primary concern is the production of fuel gas, and "beehive ovens," which function solely as producers of coke. The latter, however, are obsolete, their construction is no longer undertaken, and existing installations are used, generally, only when the demand for coke exceeds the supply from other sources. Today, all large scale coke production takes place in by-product ovens.

In the parlance of the industry, one speaks of a "battery" of coke ovens. The battery is the structural unit which comprises ten to eighty ovens and the equipment necessary for heating and flow regulation. In concept, a battery is a large rectangular block of refractory brick, containing receptacles for the coal and flowways for air and gas. Refractory brick is not a mere lining as in most other refractory ovens, but is the actual structural material of which the battery is built. In operation, temperatures in the brick structure range from 600–700° F. in the regenerators to approximately 2000° F. in the ovens themselves.

An individual coke oven is, strictly speaking, a chamber in which coal carbonization occurs. Typical dimensions of such a chamber are: length forty feet, height thirteen feet, width eighteen inches. The length of an oven is the width of a battery. Between any two ovens one finds a series of vertical heating flues, twenty to thirty in number, situated side by side along the length of the oven. Gas is burned in these flues to provide heat for carbonization. Checker-brick-filled regenerator chambers below the ovens and heating flues served to utilize the sensible heat of the combustion products to preheat incoming air and gas. Most modern batteries are of the "underjet" type, that is, a basement is provided underneath the brick structure of the ovens and regenerators to house the equipment for regulating air and gas flow. Beside providing ease and accuracy of mechanical regulation, the underjet system helps make the supply of combustion air to the ovens independent of weather conditions.

The cycle of coal carbonization begins when the raw bituminous coal is crushed to particles approximately two inches in diameter and conveyed to the coal bin which towers over one end of the battery. An electrically operated car runs on rails atop the battery and receives coal from the bin, charging each oven through holes in the oven roof. To the end that the charge may be evenly distributed in the oven, a "leveler bar" is inserted into the top of the oven from one side of the battery. This bar is part of the machine which serves to push the coke from the oven when carbonization is complete. Carbonization time varies greatly but is often of the order of eighteen hours. During this time destructive distillation of the coal takes place, the formation of coke proceeding from the oven walls inward. The distillation products pass off the top of the charge,



through standpipes in the roof of each oven, into the collecting main. Both standpipes and collecting main are situated along one side at the top of the battery. The distillate is drawn through the collecting main to by-product and benzol plants for removal of tar, light oil, and other industrial chemicals, the greater part ending as a rich fuel gas-coke oven gas.

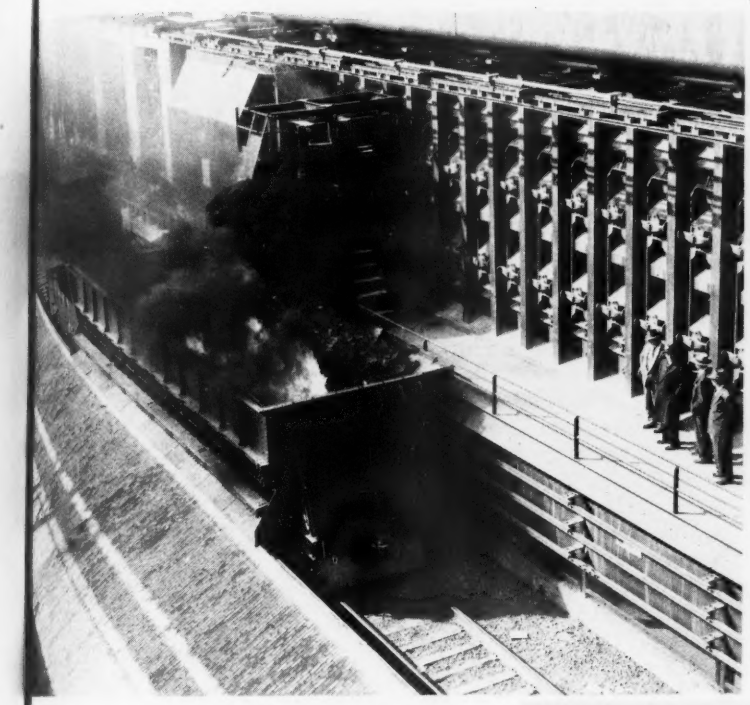
Smoking and flaming often take place when air is admitted to the ovens during the process of charging and leveling. Ovens with two collecting mains, one on either side of the battery, have been built for the purpose of eliminating this effect by more rapid removal of the gas which quickly forms during charging. This attempt has not been totally successful, but one company now claims to effect smokeless charging through the use of two mains plus modified charging and leveling procedures.

The chief problem in coking involves providing a uniform temperature from the top to bottom of the charge (a 50° F. difference is considered standard) without producing temperatures at the top of the oven high enough to crack the distillation products before they are drawn into the collecting main. It has often been necessary to undercoke the top of the charge to prevent this cracking. A solution has been proposed in which two collecting mains remove heat in the form of sensible heat of the distillation products before cracking conditions occur.

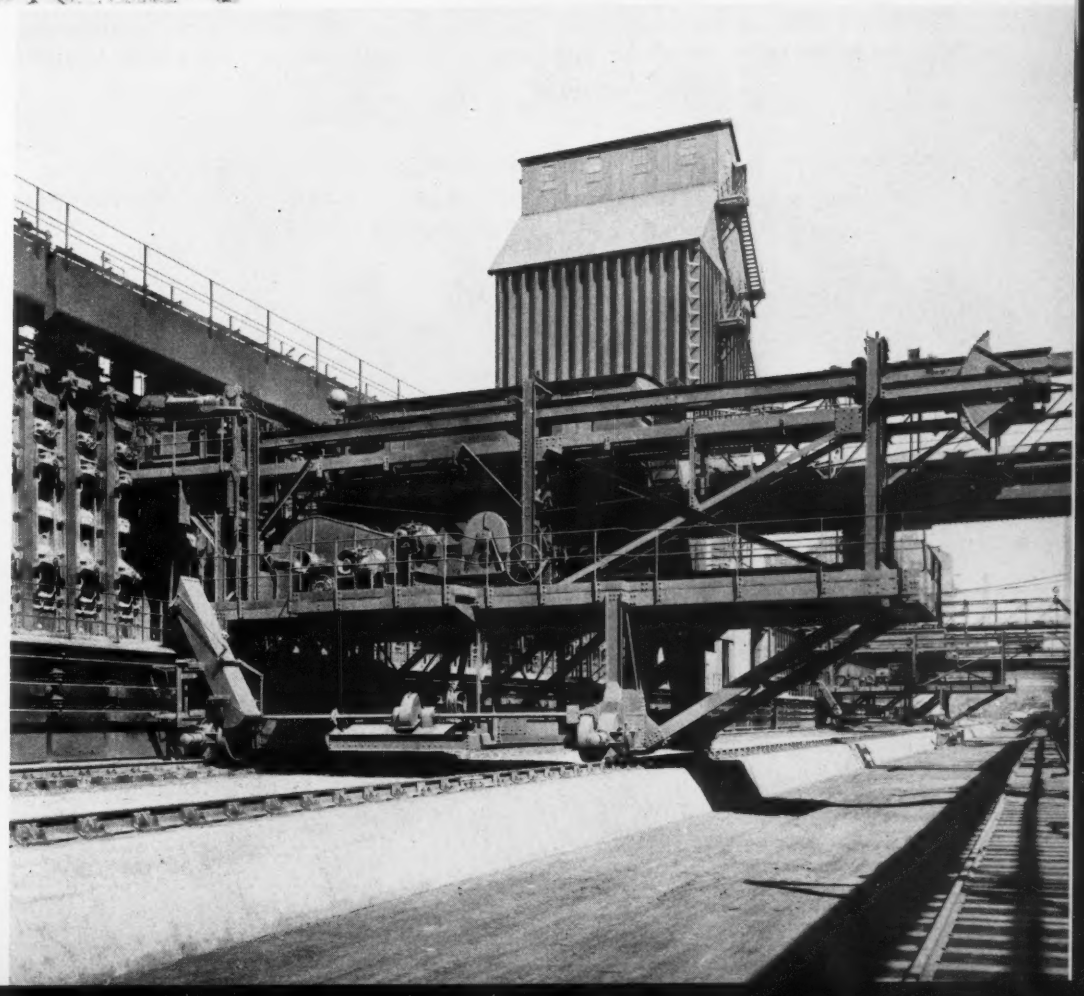
Coke oven firing utilizes so-called rich gas (approximately 500–550 B.T.U. per cubic foot) or enriched lean gas (200–300 B.T.U.). When underfiring with rich gas, the fuel burns from refractory brick nozzles at the floors of the heating flues. Since such gas does not burn with a long enough flame to provide uniform heating along the entire flue, high and low nozzles are sometimes placed in alternate heating flues so that every other nozzle is elevated approximately thirty inches off the floor. Another currently employed solution is that of mixing the rich gas with hot waste gas in a one-to-one ratio and recirculating the resulting mixture to the heating flues. The addition of waste gas sufficiently elongates the flame to provide uniform heating.

An interesting principle is involved in firing the oven with lean gas — almost the entire heat release to the oven walls in burning lean gas is the preheat of the combustion air and gas. In other words, the sensible heat of the waste gas leaving the heating flues is almost exactly equal to the heat of combustion of the lean gas. The waste gas passes through the regenerators where it gives up its sensible heat for use in preheating and is then passed on to the stack. Obviously, regenerator and gas flow design which provides for most efficient heat transfer between waste and incoming gas is of paramount importance in efficient oven operation.

(*Continued on page 40*)



Hot coke bursts into flame in the air as it is pushed from the oven.



This combination pusher, leveler, and door machine performs its operations for a whole battery.

if you can't afford television . . .

By Rane L. Curl, '51

Two of the most powerful external forces in man's aesthetic experience are music and color. It would be thought that a combination of these physical stimuli would have a correspondingly great emotional effect. This hypothesis is the basis of a novel electronic device known as the color organ. It is my purpose here to discuss the operation and construction of a *simple* version of a device, the color organ, which *could* be made tremendously intricate and costly. The circuit I wish to present was obtained from a recent periodical, so I can make no claims of originality; but I would like to bring it to the attention of the experimenter.

The organ is fundamentally a frequency and amplitude selective switch — particular ranges of frequencies and amplitudes controlling particular colors. Red was chosen to represent higher notes; green, at the other end of the sound spectrum — low notes; and blue was selected to react to frequencies between the two extremes. The selection of order of color was based on the color effects produced in operation but they may be varied to suit the individual. There are three main units employed in the operation of the color organ. First, there is a source of music which is usually a record player. Second, is the color organ itself — the device to control the intensity of colored lights as dictated by the music input. Third, we have the light box or strip containing the bulbs and filters to produce the color effects.

The actual operation of the organ is very simple. The music from the source is brought into the organ by a suitable cable and is then amplified by resistance-coupled amplifiers of traditional design, whence it is fed, by matching transformer, to the frequency selective circuits. These consist of a vacuum tube filament in series with an inductance for low frequencies, with a series resonant circuit for mid-frequencies, and with a capacitance for high frequencies. The circuit diagram shows this arrangement in the frequency channel.

When a current of sufficient magnitude flows in any one of the branches of the network it heats the filament and causes the tube to conduct. This completes the circuit containing the colored lights. The lights respond, naturally, in accord with the temperature of the filaments of the tubes, and therefore in order to follow short duration notes of different pitches it is necessary that the filaments heat and cool as quickly as possible. For this reason a light filament tube — the 71A — is chosen as the control tube. The tubes, with the grid and plate tied together, carry saturation current at all times and can therefore handle larger loads than if the grid were used as the regulator as in conventional operation of tubes.

The amplitude channel acts, in general, the same way with a few circuit modifications. The heating of the tube filaments is a function of the voltage across them. The higher voltage tap on the transformer T2 will therefore heat the filament of the tube associated with it at a smaller audio input amplitude than the other tubes connected to the same transformer. The other tubes (V5 and V6) will light in order as the signal strength increases. V4 is seen to be connected differently from V5 and V6 in regard to the external bulb circuit. Lights A are in series with lights B. Tube V4 is shunted across lights A so that with no signal lights A are lit. When a signal makes tube V4 conduct, lights A are shorted out and lights B receive the full transformer (T3) voltage. The transformer is necessary in order to allow a large change of intensity of the lights in the frequency channel. Resistances R1, R2, and R3 serve to maintain the filaments of the associated lights at a high temperature so that the thermal time lag —

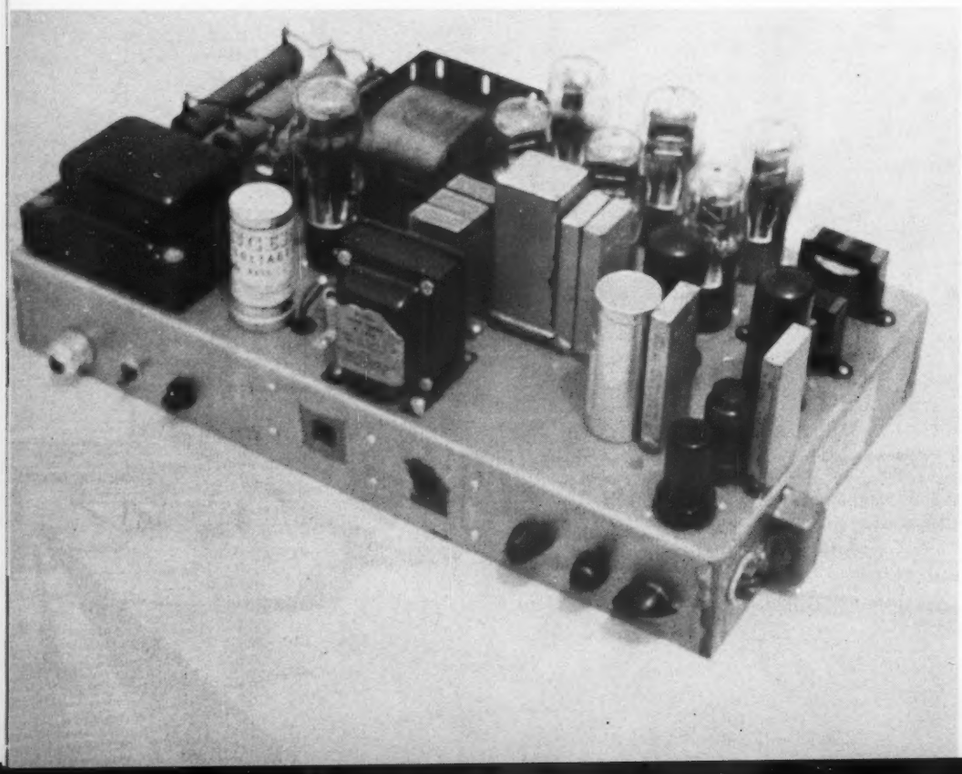


Figure 1. Proper arrangement of parts simplifies construction and wiring of the color organ.

which is considerable anyway — will not be objectionable.

The power supply is conventional. Filtering is not critical unless one wishes to have, as I did, a high gain amplifier built into the organ for low level input. This is unnecessary if the output of an associated amplifier is fed to the 6L6's.

I have discussed, to this point, the operation of the unit. I would now like to make some remarks concerning the actual construction. The base is an 11×19 inch aluminum chassis bent for the purpose. The placement of components was such for convenience in wiring and for the separation of low level stages from power stages. In Fig. (1) the power supply is in the forward left section of the chassis. The high-gain input stages are in the lower right. These feed the two 6L6's visible behind the coupling condensers. The two output transformers are seen in the upper right hand corner. Following these across the back of the chassis are the control tubes, auto-transformer, and power resistors (R1, R2, R3). The controls on the front panel are, left to right, pilot light, power switch, fuse, two openings for cores (powdered iron) of reactors, frequency channel volume control, amplitude channel volume control, and the master volume control. On the right side are seen the input connector and a coupling condenser. The power for the light strip comes out of an octal socket on the other end of the chassis. Plugs and jacks for this eight-wire cord are selected, for safety, so that a "live" male connector can never be exposed.

In the picture shown (Fig. 2) may be seen (center) the condensers for the frequency-selective network. These were made adjustable by switches on the back (Fig. 2) which would select the desired capacitor. These switches are not necessary but are a convenient substitute for experimentation.

It is necessary to construct the reactors. L1 has 1000 turns of No. 26 enameled wire on an adjustable iron core. L2 is the same but has only 800 turns. The reactors are seen mounted on the chassis in Fig. (2). The forms consist of three-eighths inch square brass tubing with brass endplates — *with the whole slotted* so as not to have a "shorted turn" or closed conduction path around the coil. The tube and endplates are insulated from the winding by sheet plastic and the two units are bolted to a piece of lucite which is then fastened to the chassis *by a different set of bolts*. This is again to prevent a closed path for eddy currents. The cores were originally laminated but these were found to absorb too much energy by eddy current losses; so powdered iron cores, using a cellulose acetate binder, were substituted. Transformer T1 is comparatively easily secured. I used a UTC R-59 for both T1 and T2 though a transformer of higher wattage rating would be desired. On T1 it was easy to find the approximate impedance matching desired, but on T2 no such luck was available. Because proper impedance values could not be secured, an approximation was made and suitable resistances added — by trial and error — to correct this mis-match. The resulting circuit modification is illustrated on the circuit diagram, but further experimentation would be desirable.

T3 presented a different problem. 1:2 auto-transformers rated at 100 watts may be secured commercially, but financial considerations made it necessary to wind my own. This was comparatively easily done after I had secured an old power transformer and stripped it down. I used the original laminations and core insulator. It was necessary to construct a winding jig of wood which would be mounted on a lathe for winding. The winding data I secured from the 1948 ARRL Handbook — Table 7-I, page 240. A total of 734 turns was used — midtapped at 367 turns. Double cotton covered enameled wire is preferable and use of a good grade of lacquer for painting individual layers is recommended. Shellac may be used *if* it is allowed to dry, by heat.

The light strip consists of eleven bulb sockets arranged in individual cubby-holes (Fig. 3) in a wood box. The low wattage and intermittent nature of their use make for perfect safety in using wood. The colors are produced by colored cellophane bound between two pieces of glass. Use light-colored cellophane and double or triple layers if a darker filter is desired. The blue now employed by the author will have to be replaced as it is too dense. Remember, the light bulbs, operating at low voltages, are rich in red and poor in blues; so the blue filter should appear by sunlight lighter than the red filter. A male chassis-mounting octal socket is used as the power connector for the strip.

Use care in wiring and watch out for high voltages. I hope yours works, too!

(*See page 22*)

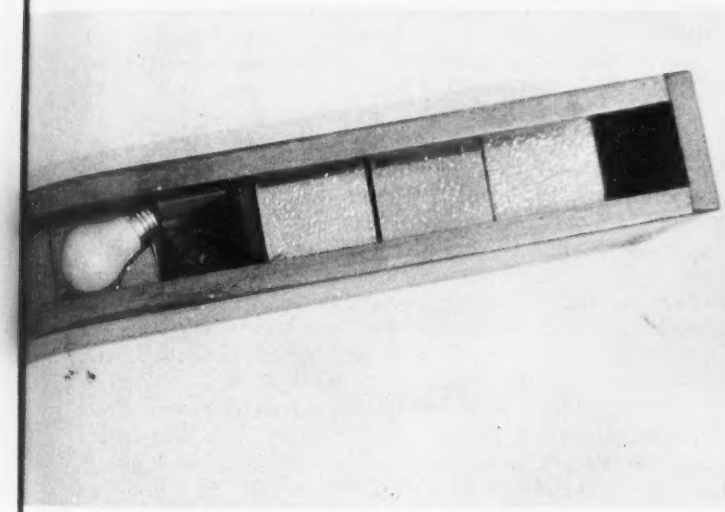


Figure 3. The actual color-producing instrument is a simple woodworking job.

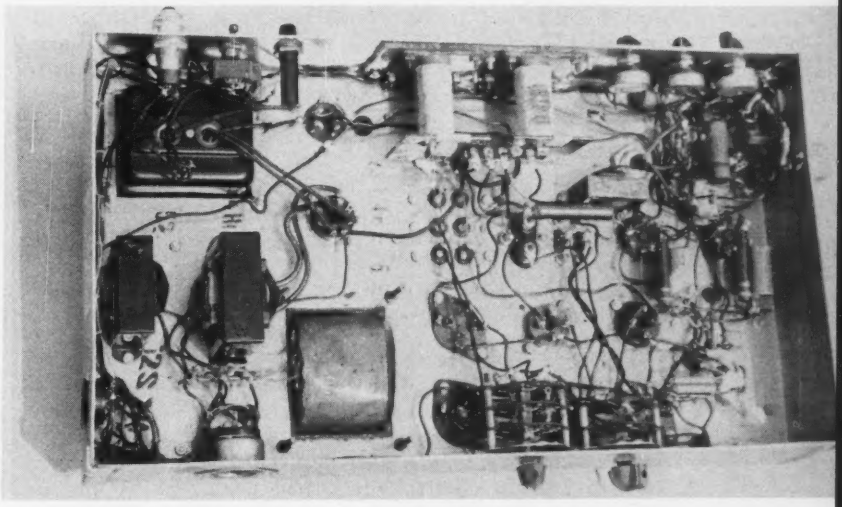


Figure 2. Wiring the color organ is simpler than would be expected from the many parts above deck.

sears: the man and his course

the man

By Milo Backus, '52

"Answers will be found in the back of the book to the odd-numbered problems." This immortal phrase. as familiar to physics students as F = ma, is the work of Professor Francis Weston Sears. It has been introduced through his outstanding first and second year physics textbooks to students in almost two hundred universities and colleges throughout the United States and Canada, including Cal Tech, the University of Chicago, Columbia, Cornell, Princeton and Yale. The famous *Principles of Physics* series cover mechanics, heat, sound, electricity, magnetism and optics. A new volume on thermodynamics and statistical mechanics has just been added to the series.

Authoring and heading the first and second year physics courses has taken up most of Professor Sears' time. He has not been able to do any scientific research since 1932 when he completed his work on the measurement of the Joule effect and electron orbits in the Barkhausen-Kurz effect. However, he has taken time off to work for the American Standards Association as chairman of a committee working on standards in the general field of optics.

Born in Plymouth, Massachusetts on October 1, 1898, Professor Sears hit World War I at fighting age. He laughingly reports that he took part in the "Battle of Boston Harbor." That battle largely consisted of sitting out in the harbor on a tugboat and for excitement occasionally bringing a foreign boat into port.

After the war he decided to enter Tech, partly influenced by his father, who was a member of the Class of 1868, Tech's first graduating class. Professor Sears, then a Course I man, entered Tech in its first year across the river. "Tech was quite different," he says. "Maclaurin was president. There was no *T. E. N.* and no *Voo Doo*. I never thought when listening to Professor Durs' lectures in 10–250 that I would some day be in the same spot." In 1921 he graduated Course VIII and in 1924 received his S.M. Sears has been a member of the faculty since 1921 and was appointed Professor of Physics in 1944.

As a student at Tech, Professor Sears' only extracurricular activity was the Glee Club, but when the squash courts were built after he had graduated he immediately became interested and until a year ago has played steadily. A more recent interest in boats led him to build a Snipe which even he admits turned out quite well. Besides the Snipe his fleet is enlarged by a cabin cruiser docked at Savin Hill.

Professor Sears is very proud of his wife — a 1923 graduate of Simmons. He claims that she was much more active in college than he and last year was president of her alumnae association. The Sears now reside in Belmont in a handsome home done in modern architecture.

the course

By Prof. Francis W. Sears

The Massachusetts Institute of Technology recognized the importance of a sound training in Mathematics and Physics when it pioneered in introducing full two-year courses in both Mathematics and Physics, to be taken concurrently by all of its first and second year students in Engineering and Science. Other institutions of a similar nature are now following our lead, but the undergraduate curriculum at M. I. T. differs from that at most other schools in the emphasis it places on these fundamental subjects, and the fact that the entering freshman begins his study of both on the first day of his first term. The departments of Mathematics and Physics work in close cooperation to plan the curriculum in each course so that the mathematical tools required in the Physics course are taken up either before, or at the same time, they are needed in Physics. The simultaneous discussion of, say, the significance of a derivative or of a vector product, from the point of view of both the mathematician and the physicist, we believe to be of great value in the teaching of both subjects.

The subject matter covered in the two-year Physics course does not differ greatly from that of the usual one-year program. It may appear that one topic follows another with startling rapidity, but actually the pace is a relatively leisurely one by comparison. This does not mean that the course is a leisurely one, as many witnesses will be willing to testify. The additional time made available by spreading the subject matter over two years enables each topic to be treated with greater thoroughness and attention to detail.

The problem of teaching Physics to a student body like the one at M. I. T. is very different from that facing the Physics department in a Liberal Arts college. It can be said that we have no problem, in the sense that the students as well as the school realize fully that Physics is a professional subject and not just a course to be taken for credit. It has been a most gratifying experience to note how, as the course has developed and grown over a period of years, the students have responded to the challenge of a more advanced presentation of one topic after another and now take in their stride a large amount of material that a generation ago would have been reserved for intermediate or advanced courses.

If you are just beginning your course in Physics, I should like to say a word to you personally. You have come to M. I. T. because you believe that it affords the best environment in which you can spend four years of study. Your lecturers and instructors in Physics want to see that you make the most of this opportunity. Their responsibility is not primarily to teach you physics, but to help you to study physics. All of us, staff and students alike, are still learning. Some have a few years jump on the others, that is all, and we want to help you to catch up.

making construction materials work

Steel and John Hancock

By Robert S. Griggs, '49

The purpose of engineering, stated in its most broad and general terms, is to realize the utmost possibilities from the materials and phenomena known and understood, and to let that realization be inexpensive enough that everyone can enjoy its benefits. The world has always had tungsten, but it took engineering to make filaments of it and put them into electric light bulbs to give the world a better light than the candle. There has always been oil underneath the ground, at least as long as man has been around, but it was engineering that found a greater use for oil than foot-warmers and the lamps of China. Engineering has learned what materials can do, and how better ones can be developed.

The study of cement brought forth Portland cement only a little over a century ago. The further study of how cement can bind sand and gravel into concrete helped develop cement from a material of limited architectural and adhesive use to one which is quite basic to today's construction. Combining concrete with reinforcing bars of steel to give the strength in tension which concrete itself lacks produces a strong, practical type of construction which is fast and cheap to build. In steel, the Bessemer process and the rolling of ready formed I-sections enabled the production of steel members which could be made economically enough to be a practical construction material. The study of the properties of that steel, and the improvement of such properties, coupled with the formulation of the theory of what happens when a structural member is loaded, has brought structural steel to its present important position.

But even with these mighty advancements, it is questionable that building materials are used to their best advantage. Civil engineering has been termed the most conservative engineering field, and one can see what is meant when looking at any large modern building going up.

When the Greeks built the Parthenon, they hewed out tremendous blocks of marble, hauled them to the Acropolis, and set them one on top of another all around the foundation to form the wall of the temple. This wall, with the help of equally massive stone columns. supported the heavy stone roof. And, up until only about seventy or eighty years ago, piling stone upon stone, or brick upon brick, was the only way known that a large building or even a bridge could be constructed. Some sort of beam or arch extended from wall to wall, and carried the floor and roof loads into the walls, for transfer down into the foundation. When the walls became too high, it was necessary to lean one building upon another, or use many interior bearing walls too, or to buttress the sides to keep the walls from toppling over. Little was known, and little more cared, about how much their materials could carry, for their massiveness usually kept them from failing. When failure was experienced, as with London Bridge, which kept falling down, they just rebuilt the structure in greater bulk until it would eventually stand up.

Now, with structural steel to support a building, a radically different type of construction from the old bearing wall type comes about. Instead of supporting everything upon the walls, a steel skeleton is built, one which is designed to be strong enough to carry not only itself, but everything else which goes into the completed building, including the walls. These walls are now called curtain walls, because their only purpose is to close up the building so that it can be used, and to give the desired architectural effect on the outside. The stone used does no work at all, and does not even have to carry its own weight down into the foundation, for the steel framework inside the building does all that for it.

So why use stone at all? It is an awesome experience to stand on the upper floors of the new John Hancock building during its construction, and watch block after block of stone, each with its own identifying number, being hoisted up the side, swung into place, fastened by two steel bars to a steel lacework around each floor, and mortared to the stones beside and below it. Here was a building with unique design features which had been widely mentioned. It rested on steel H-piles driven one hundred feet to bed rock. Yet one of the purposes of these piles was to support these thousands of blocks of useless stone, each half a ton in weight, and each contributing only eight or ten square feet to the facing of the building. Advanced design, it was described — "atom-bomb proof" — to tie these stones so securely to the building frame that not one could fall out, even in an earthquake or a severe explosion. Advanced, too, it is said, to substitute a light steel panel throughout on the interior walls to save the expense of putting up lath and a half-inch or so of plaster, and how much lighter that made the floor load! How many times greater would the potential saving be in substituting some similar steel panel outside the building, in place of all these individually measured and cut and polished pieces of rock!

It has been estimated that if steel panels had been used on the outside of the Empire State Building, instead of the stone which was used, some thirty per cent of the weight of the structural steel in the building could have been eliminated, representing a saving in that respect alone of over a half a million dollars out of a total cost of twenty-five million. This does not even attempt to estimate how much would have been saved by eliminating the individual hewing, laying up, and tying in of one hundred and three stories of stone.

But steel can do much more than just save money. Obviously, the easiest way to save money in putting up a building would be to cut down our factor of safety from four or five to the 1.1 or 1.2 which structural engineers work with in the design of airplanes. But builders are dealing with a much more important structure than an airplane, and one which must last a good deal longer. They must put enough material in so that much can decompose and still be safe, and so that much different loadings from those originally designed for can occur without danger. They want to be absolutely sure our building is safe, and steel panels can do a great deal more toward making it safe than can the stone we now use.

Now, to be sure of having adequate bracing against

(*Continued on page 28*)

low speed aerodynamics

By Henry R. Jex, '51

Thousands of scientists are at present engaged in a tremendous research program on supersonic flight, and for years subsonic design problems have been attacked; yet practically nothing has been done at the very lowest end of the air speed range. Recently, however, there has been a revival of interest in what is known as "Low Speed Aerodynamics," and a public review of some of the latest developments in this field of aeronautics is given here for the first time.

Let us first limit ourselves to a certain region of flight, for as we shall find out later, the aerodynamic effects depend not only on speed, but on the length of the body in the airstream as well. Suffice it to say for now that any surface over which the air passes for less than one foot and which has a relative velocity of *under one hundred miles per hour* will be considered in the realm of low speed aerodynamics.

Of course, model aircraft of all types fall into this category, and most past contributions to low speed aerodynamics have been of a qualitative nature as remedies to the erratic behavior of these small airplanes. The same erratic behaviors which models experience was noted by early wind-tunnel experimenters. These men soon found that it was easier to build larger wind tunnels than to correct for the discrepancies which small, low speed tunnels produced. Thus, low speed performance was left to qualitative guesses.

However, during the years from 1935 until the war, the interest in low speed aerodynamics was reborn. In this country, two of the leading model builders of their time began to apply scientific reasoning to the behavior of their airplanes. Charles H. Grant, a graduate of the School of Military Aviation at M. I. T., developed his own ideas of stability and control, while Frank Zaic retained "full-scale" theory but made an effort to find the reasons for the differences between it and observed phenomena at low speeds. Although Mr. Grant did publish numerous empirical formulas and remedies, there was no general theory until 1937 when some professional scientific testing was done in Germany. Professor F. W. Schmitz, of the University of Cologne began a series of tests with small and inexpensive wind tunnels which were carefully designed to simulate free flight air conditions of small model aircraft. The results of his work will be given farther on, but it is interesting to note that these results were the most accurate until just four years ago.

In 1945, the Low Speed Aerodynamics Research Association (hereafter abbreviated L.S.A.R.A.) came into existence as a result of some arguments among British model builders. The most important information brought to light so far by this organization is that full scale theory is acceptable for use on low speed problems, but that the magnitude of the few exceptions is all important! Let us consider some of the problems and their solutions.

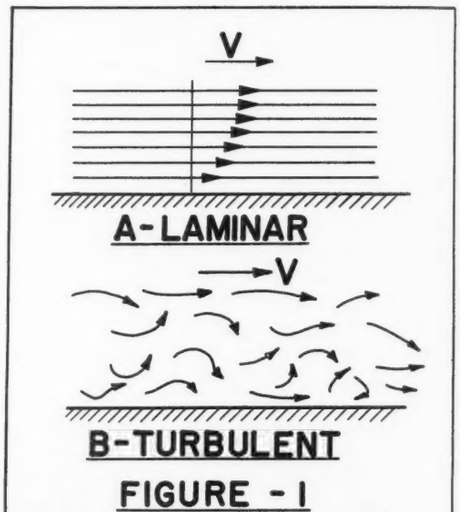
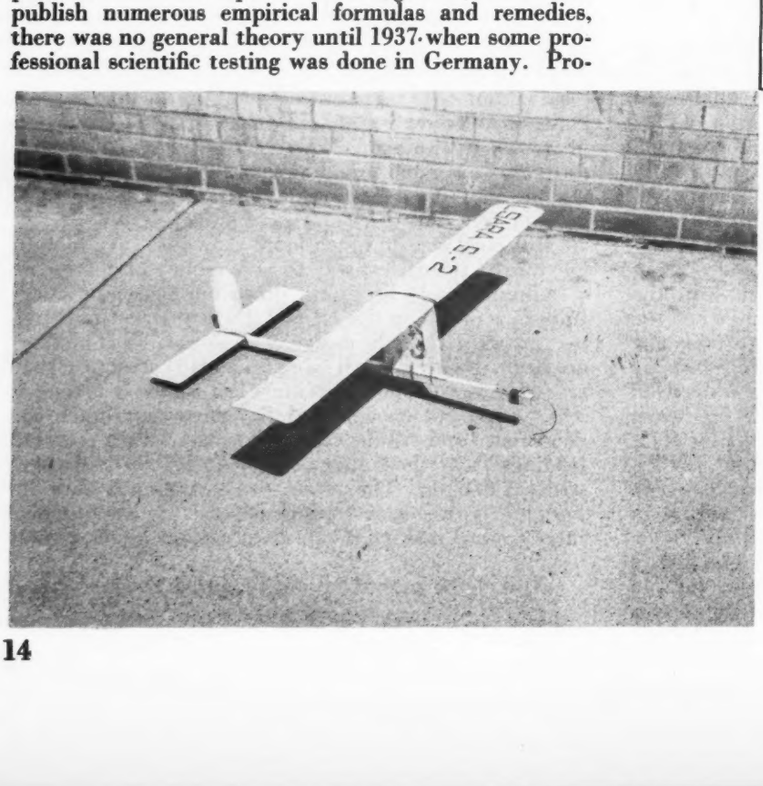


FIGURE - 1
BOUNDARY LAYERS



This test glider has adjustable moments, balance, and areas. Measurements are taken along a straight glide path.

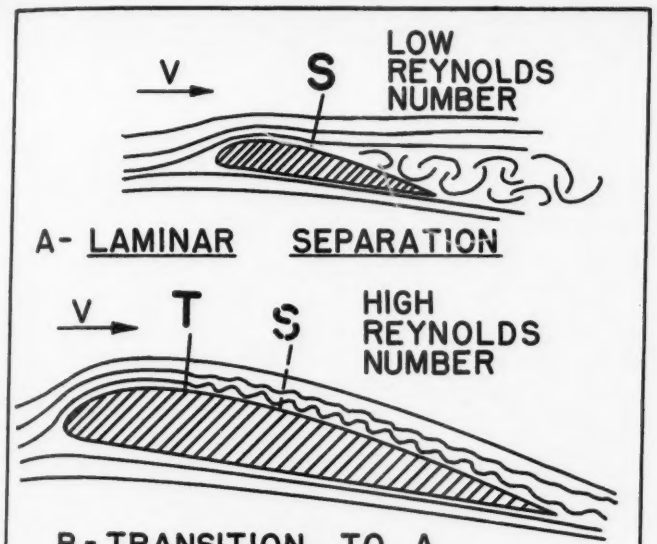


FIGURE-2
EFFECT OF REYNOLDS NUMBER

As was previously mentioned, the performance of aerodynamic objects depends upon their length as well as the velocity of air over them. This relationship may be visualized as depending on the total mass of air over a wing during a small interval of time, and a very simple function known as the *Reynolds Number* has been defined:

Reynolds Number = constant × Velocity × Length

$$R = \frac{\rho}{\mu} VL.$$

$\frac{\rho}{\mu}$ is known as the kinematic viscosity and is nearly constant for most sea-level conditions, ρ being the mass density and μ the viscosity of the air. L is the distance from the leading edge of the airfoil to the point under consideration. The important point is that the Reynolds Number depends on *Velocity* times *Length*. In other words, if similar behavior is desired for two geometrically similar, but different sized shapes, then the smaller must travel faster until the Reynolds Numbers are equal.

The theory behind this observed phenomenon has not been fully developed mathematically, but qualitative explanations are fairly complete. It seems that the fly in the ointment, as far as the wing is concerned, is the *boundary layer*. The boundary layer is a thin (.001 to .3 inches thick) layer of air adjacent to the surface of an airfoil in motion. Two types exist: the *Laminar* and the *Turbulent* layers. Referring to figure 1, we see that the laminar boundary layer (A) is a series of sheets of fluid moving past the body with parabolically increasing velocity. There is no intermixing of the layers, and the only drag is due to skin friction. On the other hand, the turbulent boundary layer (B) has no such regularity. There is an oscillating and intermixing flow in which the slow particles near the surface are carried out to higher velocity regions, and high velocity particles are carried in next to the surface to impinge on it. Consequently, the turbulent boundary layer had *more energy* per unit volume as well as a higher friction drag. Remember the important points: Laminar boundary layer — low drag — low energy; turbulent boundary — higher drag — higher energy.

Now, how do these facts influence the performance of an aerodynamic shape? For some time, it has been known that a laminar boundary layer exists in air flows of low Reynolds Number. This laminar flow is a lazy creature and does not have enough "energy" to keep close to a surface once it has been pushed away. This parting of the flow from a wing is called *separation* and is likely to occur just beyond the lowest pressure point of the airfoil, as shown in figure 2-A. Separation is accompanied by a *decrease* in lift because less airfoil remains to deflect the air, and an *increase* in drag due to the energy absorbed in the eddied wedge of air behind the separation point (S).

Now let us consider the turbulent boundary layer. An air flow which has a turbulent boundary layer *does not* separate as readily as flow with a laminar boundary layer (figure 2-B). Having more energy than the laminar flow, the turbulent boundary layer sticks to the wing for a much greater distance. Lift is higher and drag is lower in this case due to the absence of serious separation effects.

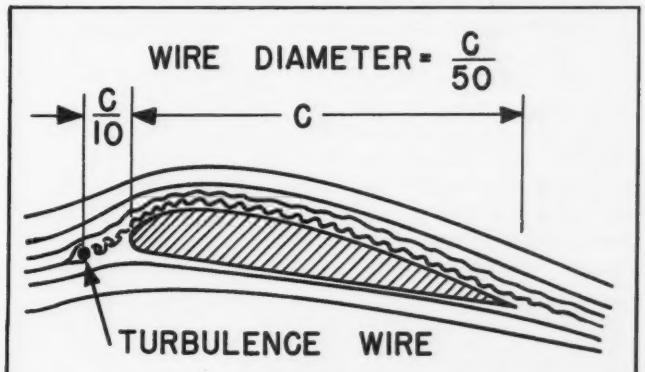


FIGURE-3
ARTIFICIAL TURBULENCE

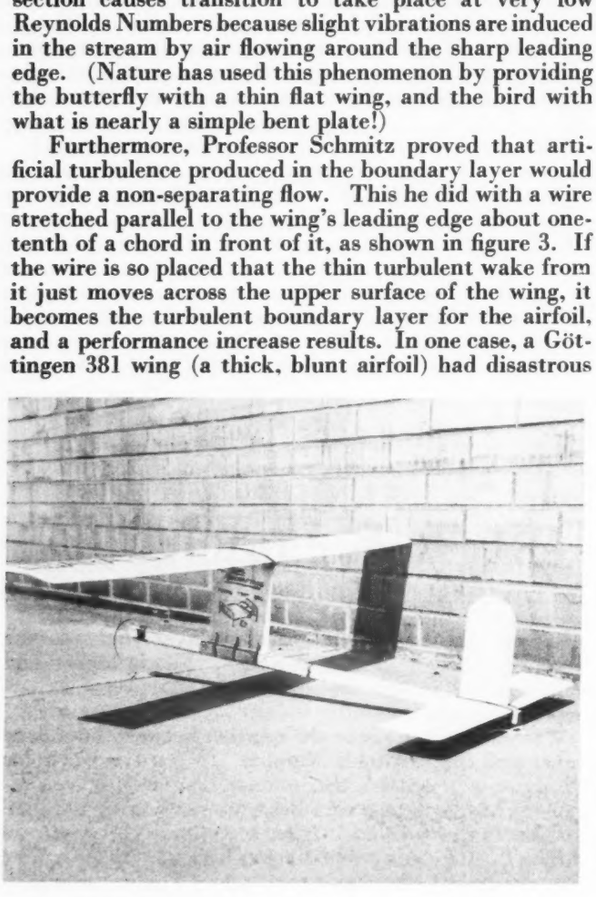
We will now go into the relation between boundary layer and the Reynolds Number. When the Reynolds Number is increased, the laminar boundary layer suddenly changes into a turbulent flow at a critical value. In observing the smoke from a stationary cigarette in still air, note how the smoke goes straight up for a time and then suddenly begins to wiggle. This is the transition point between laminar and turbulent flow; and although it is easy to see in practice, it is not easy to predict in theory.

In figure 2, the separation point is marked "S," and the transition point, "T." Let us assume the velocity over both airfoils is about twenty miles per hour, but that the upper airfoil has a chord of only one-half a foot while the lower is one foot wide. For both airfoils, the theoretical separation point has been calculated by the L.S.A.R.A. to be forty per cent behind the leading edge. For the smaller airfoil, then, the Reynolds Number up to the separation point is about 37,000 (as calculated from R = const. × Length × Vel.), while transition takes place at 45,000 (from Professor Schmitz's results). As the boundary layer at the predicted separation point is laminar, separation *does* occur, and the airfoil is said to be *sub-critical* (see figure 2-A). However, as the

forty per cent point on the larger airfoil is twice as far back, the Reynolds Number is doubled, 74,000, and transition has occurred before the air flow separated (see figure 2-B). Because the boundary layer is now turbulent, separation effects are negligible, and the condition is termed *super-critical*, the critical designation being reserved for the theoretical case at which separation and transition occur simultaneously.

The ideas of separation and transition have been known for some time, but their importance in low speed aerodynamics was not brought out until recently. Professor Schmitz made tedious tests to determine the effect of airfoil shape on the transition point and critical Reynolds Number. His tests not only showed the poor performance of conventional full-scale airfoils at low speeds, but they showed that an ordinary flat or bent plate was far superior. The thinness of this type of section causes transition to take place at very low Reynolds Numbers because slight vibrations are induced in the stream by air flowing around the sharp leading edge. (Nature has used this phenomenon by providing the butterfly with a thin flat wing, and the bird with what is nearly a simple bent plate!)

Furthermore, Professor Schmitz proved that artificial turbulence produced in the boundary layer would provide a non-separating flow. This he did with a wire stretched parallel to the wing's leading edge about one-tenth of a chord in front of it, as shown in figure 3. If the wire is so placed that the thin turbulent wake from it just moves across the upper surface of the wing, it becomes the turbulent boundary layer for the airfoil, and a performance increase results. In one case, a Göttingen 381 wing (a thick, blunt airfoil) had disastrous



Visible in this view of the test glider is a low-speed laminar type airfoil — one of six under test.

separation even at moderate speeds, but the addition of a "turbulence wire" decreased the sinking speed of the glider by three hundred per cent; i.e., it descended one-third as rapidly! Other types of turbulence producers in which the wire is placed directly on the wing surface have not been successful. The L.S.A.R.A. has recently shown that the laminar boundary layer on very small wings is extremely stable, that is, hard to disrupt or make turbulent. For this reason, an object on a small wing intended to cause a turbulent boundary layer will either be too small to affect the stable laminar flow, or else it will be so big as to cause separation itself! Still further, the pre-leading edge turbulence wire must be placed exactly on the upper wing streamline, or its effect is lost. With wind tunnel models and flying models which change the angle of attack to the airstream very often, the turbulence wire provides good performance only for a very limited range.

The L.S.A.R.A., after it had demonstrated the stability of the laminar boundary layer and had satisfied itself as to poor performance due to separation on conventional wings, decided to attack the problem in another way. On a conventionally shaped airfoil, as in figure 2-A, the separation point moves steadily forward as the angle of attack is increased. Why not, then, let the laminar boundary layer exist, but cut down the size of the separation wake at any angle of attack below the stall? The point at which separation pressure gradient is obtained was consequently moved as far *back* as possible, and the portion in front of it was kept straight in order to make the curvature sharp only at this rearward point. Results were most satisfactory, as we see in figure 4, where the separation point is shown for varying angles of attack. The dotted curve is for the conventional airfoil, the Clark Y, while the solid line shows how the separation point stays near the trailing edge of the new L.D.C.-2.

The separation wake is thus kept to a minimum, and the airfoil has more lift and less drag. In this case a blunt nose is preferable; no turbulence is desired as it only raises the skin friction drag without preventing separation. At present, both types of airfoils and corrections are undergoing extensive wind tunnel and glide testing under the direction of the L.S.A.R.A.

Glide tests with actual models are the only ultimate proof of the efficiency of new airfoils, but unfortunately good quantitative accuracy is difficult to obtain. Comparative results seem to show that the laminar type (L.D.C.-2) airfoils are superior to those usually used on model aircraft, and one accurate set of tests made in

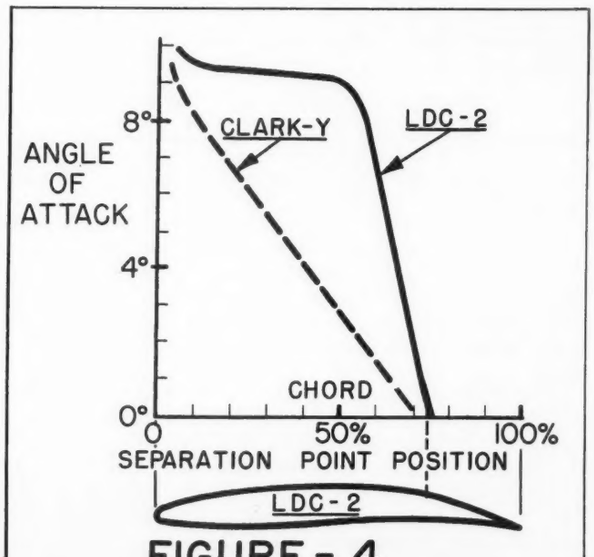


FIGURE - 4
"LAMINAR" AIRFOILS SEPARATE FARTHER BACK.

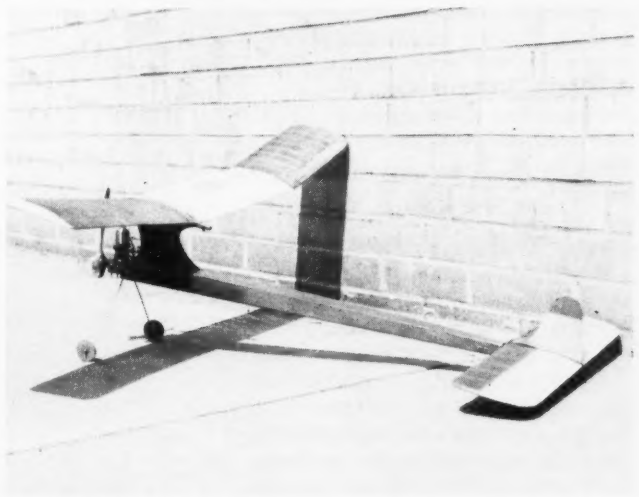
Canada by J. S. Luck showed an improvement in glide from 5:1 for the best conventional section (N.A.C.A. 6409) to 7.5:1 for *both* the L.D.C.-2 and the thin, sharp Schmitz type airfoil. An accompanying photograph shows the author's test glider for which six test wings have been built by the Tech Model Aircrafters. Tests so far have been inconclusive due to stability troubles from the simple straight wing, but indications are in favor of the special low speed airfoils.

There is little advantage, however, in developing a superior airfoil, if the airplane which uses it cannot employ it to the fullest efficiency. Strangely enough, it was noticed during the glide tests of experimental airfoils that the least efficient airframes often caused the airfoil to operate best.

It has been known for quite a while that the aerodynamics of the *wing* affect the *stability* of the airplane. but these tests show, in addition, that the *stability* of the plane affects the *wing's performance.* To bring out the importance of this new discovery, we must realize first that a wing loses its lift only after a certain maximum lift has been *passed* — this is known as a stall, and it is characterized by the plane's *dropping* off on one side or in a vertical direction. Now, to pass this maximum lift, the center of gravity of an airplane must be moved back (assuming level flight). However, the L.S.A.R.A. found that the dipping maneuver which accompanied a backward shift of weight to achieve the least sinking speed was not always a "stall" at all, because the maximum lift often was not approached! It is theorized tentatively that this condition is a kind of "phugoid oscillation," set up by low Reynolds Number effects on the *airfoil* and aggravated by a large moment of inertia and small stabilizing moments on the model.

Glide tests have shown that a *single wing*, when used on a streamline model could be made to give only half the lift it would give on a box type model; any further increase only resulted in the unstable oscillations being set up. Flying wings and streamlined towline gliders are very susceptible to this phenomenon. A vicious case of oscillations was noticed on a flying wing which, when launched from the top of a five hundred foot cliff, proceeded first to dip with increasing violence until it finally went into a series of colossal seventy-five-foot *loops* before striking the bay below!

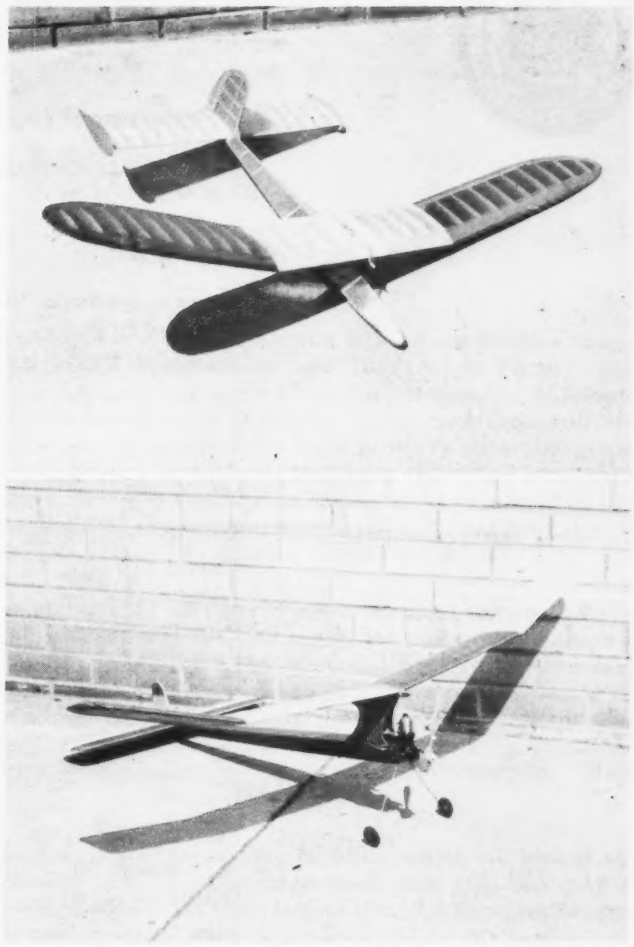
The answer to high performance in calm air then, seems to lie in long tail moments, and low moments of



Note the single blade propeller, short nose, and long, thin nose for efficiency in this free-flight model.

Upper photo shows a conventional towline model glider.

The compression-ignition engine and "pylon" wing mount on a high efficiency free flight model are evident in lower photo.



inertia, but the contradictory nature of these features and the strength requirements of the aircraft make their incorporation most difficult. The power model shown in the photograph has these features. Notice the long tail moment arm and the short nose moment arm (forty per cent of the mass of the entire plane is in the compression-ignition engine). By keeping the construction simple, a light but strong structure was possible. An L.D.C.-2 airfoil is used on the wing, and a modified version on the tail.

On the day of its test flights, the soundness of the previous observations and theories was borne out. A conventional rubber-powered model, whose center of gravity had been moved dangerously back, was flown first. With the cause of oscillations present, and the high moment of inertia of the rubber motor (fifty per cent of total mass) along with a short tail moment to heighten the effect, this model experienced a perfect set of phugoid oscillations. Phugoids are distinguishable from stalls in that in phugoid oscillations, the model rises nose up, then *rotates* downward about the span-axis, only to regain speed and repeat the dip *more violently;* whereas a stalled model drops from the nose-high position until flying speed is attained and may or may not repeat the performance. To prove the difference, the engine model (same size and mass as the rubber model) was then trimmed tail heavy. True to

(*Continued on page 34*)

tech engineering news

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from the editor's notebook

Gathered during the summer . . .

A Bureau of Standards technical report issued last June had a title which foretold interesting copy for engineering students — "The Fallacy of the Best Two Out of Three." On wading through the three mimeographed pages, we wished we had done it sooner. It seems, says the report, that, given three measurements of a quantity (three measurements are evidently the fewest number one would want to make and not have to worry about his grade when reports are handed back), one of which is a good deal away from the other two, more accurate results are obtained by averaging all three, rather than taking what appear to be the "best" two. The report backed up this fact with figures, but we did not need to be convinced — we own, stored away in our "bibles," several rather expensive personal proofs.

It is about time . . . although here in October this is old news, medical scientists have banded together to protect workers in the field from the well organized and often damaging attacks of anti-vivisectionists. Under the auspices of the National Society for Medical Research two one-million-dollar libel suits have been brought to protest against loose use of the words "torturer," "sadist," "tormented," with reference to researchers and test animals. Victory for the medical scientists would represent a strong blow for freedom of research. We have often wondered whether or not an appendectomy is considered vivisection. May we wish the doctors luck.

Here is an interesting variation on the laws of something or other which we picked up somewhere: If two men each have a dollar and they exchange, each man still has only a dollar and there is no progress. However, assume that each has an idea; let them exchange; and see what happens. Each now has two ideas.

K. K.

We, the editor, speak . . .

RANE CURL, '51, built, as you may know by now, a gadget known as a color organ. Having been treated to Mozart's Symphony No. 40 "with Rane Curl at the color organ," we asked that he write it up for those who cannot afford television. Perhaps you too have been looking for an excuse to keep a room dimly lit without being too obvious — well, here it is.

There are no doubt other equally useful toys hidden away in the recesses of the minds of Tech students with nothing better to do. If there are, perhaps *T. E. N.* might serve as a medium through which they can be spread throughout the Institute.

Two years ago *T. E. N.* published a story describing an activity new to M. I. T. — the campus radio station. In this issue we present a summation of the advances made by WMIT in those two years. Here is one progress report which is worth reading, simply because of the speed of the progress described.

With all the noise about sub- and supersonic aerodynamics, HENRY JEX, '51, thought that his pet field, aerodynamics at the other end of the speed spectrum, had been neglected. He has written an article to correct the situation, within *T. E. N.*'s readership anyway. For some reason which we cannot quite put our finger on, this article does not read like a textbook chapter, although it might serve as one.

Now that the John Hancock building is complete, we find that all the stone used in its construction was not such a good idea. That is what BOB GRIGGS, '49, tells us in his article extolling the advantages of steel on outsides as well as insides of buildings. The article was written for May's *Tau Beta Pi* issue, but there was no room for it then.

Uniformity gained by "Centrifugal Casting"

The great majority of cast iron pressure pipe produced today is cast centrifugally, in metal or sand-lined molds.

When this mechanized process was introduced 27 years ago, its potentialities for improved production controls were evident. For human fallibility was largely replaced by machine accuracy based on scientific principles.

The improved production controls made possible by the centrifugal casting process have long since been realized. Hundreds of millions of feet of centrifugally-cast-iron pressure pipe are now in service. All of this pipe is more uniform in metal structure, in wall thickness, and in concentricity, than pipe not centrifugally cast.

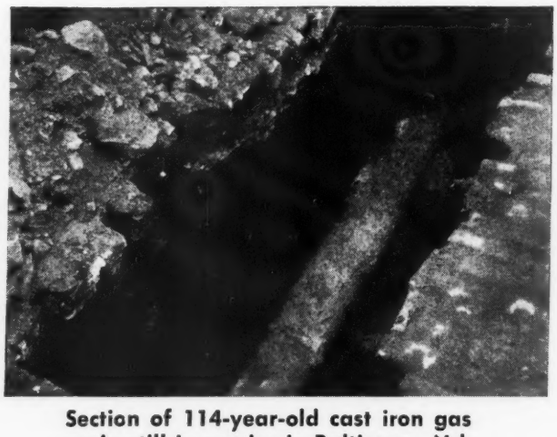
Better production control means better pipe; it results in greater uniformity of quality.

Production controls in cast iron pipe foundries start almost literally from the ground up with inspection, analysis and testing of raw materials; continue with constant control of cupola operation by metal analysis; and end with rigid tests of the finished product.

By metallurgical controls and tests of materials, our members are able to produce cast iron pipe with exact knowledge of the physical characteristics of the iron before it is poured into the mold of a centrifugal casting machine.

Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction.

Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Avenue, Chicago, 3, Illinois.



Section of 114-year-old cast iron gas main still in service in Baltimore, Md.

CAST IRON PIPE SERVES FOR CENTURIES

New Fields of Research and Achievement

. . . FROM THE AIR

* * *

Rare Gases Now Available in Quantity Offer Challenging Subject for Study

Among the least known of the elements have been the rare gases—Krypton and Xenon. Occurring in the atmosphere in concentration of one part per million for Krypton, and one part per twelve million for Xenon, their very scarcity gave them the status of "scientific curiosities" for a long time.

But now, these gases are available in quantity in refined, compressed form. As these gases assume the different role of "new" materials, their individual physical and electrical properties are finding interesting uses.

The increased efficiency of hot cathode (fluorescent) lights is a direct result of using Krypton as the gas filler. The brightest light ever made by man is produced by an electrical discharge through a column of Krypton . . . these lights are used to penetrate fog at airports.

Xenon is replacing mercury vapor in industrial (thyratron) tubes, to avoid low temperature condensation troubles. It is Xenon that makes practical the "repeater" (gas discharge) photographic flash lamp—the low resistance and good spectral range of the gas both being important. In the fast-growing field of atomic energy, the rare gases become increasingly important. The use of such gases in Geiger Mueller counter tubes is well familiar.

Chemists and physicists on many types of projects will want to study the possible value of these gases in their fields. Others may desire to work with the rare gases as such, contributing to further information in this expanding subject. Graduate students especially may find rare gases a fascinating, challenging, and wide open field for doctoral thesis.

In whatever connection, scientists who may want more information on Krypton, Xenon, Argon, etc., are invited to write us fully. Please write Dept. LAP, Room 1502, 30 East 42nd St., New York 17, N. Y.

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AND CARBON CORPORATION

30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

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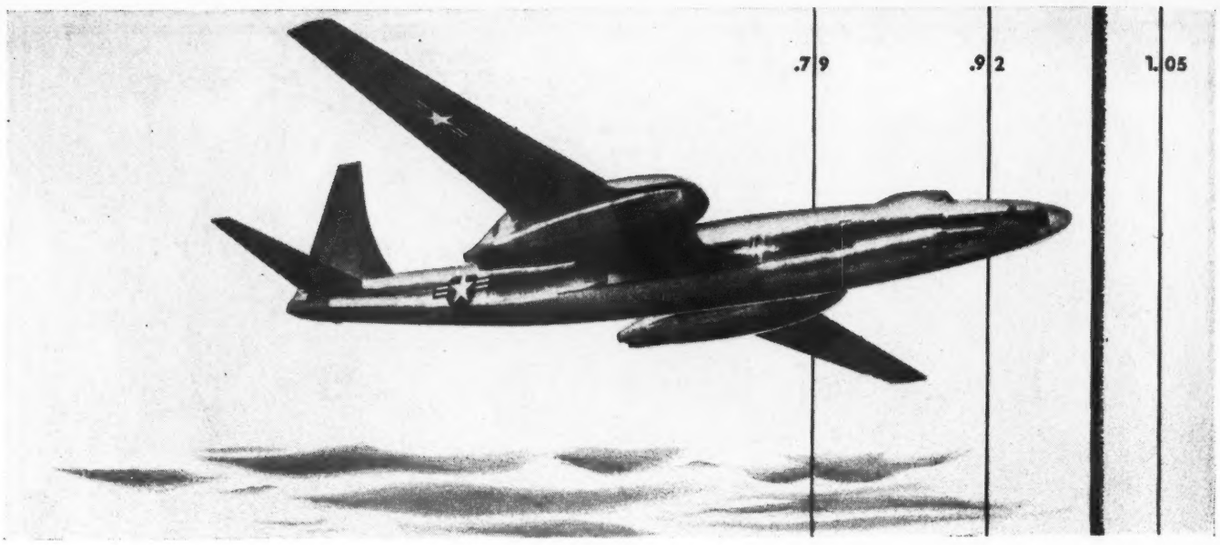
NATIONAL Carbons • EVEREADY Flashlights and Batteries • ACHESON Electrodes • PRESTONE and TREK Anti-Freezes



The jet bomber that approaches

the speed of sound on SKF ball and roller bearings

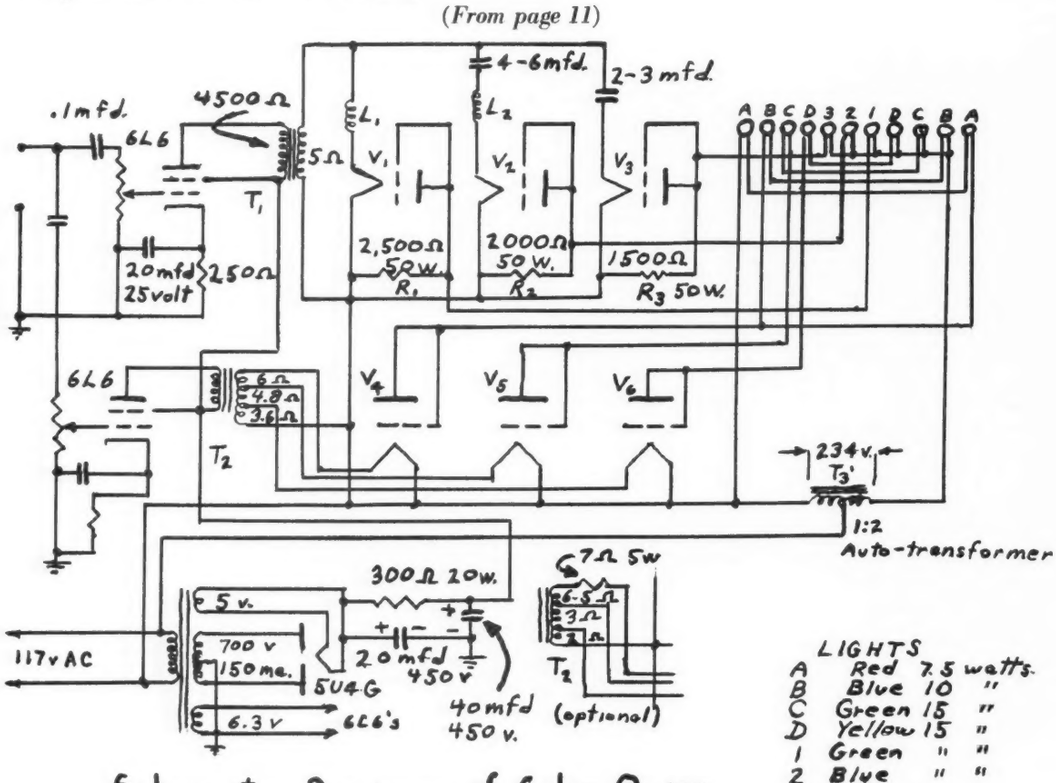
The Consolidated Vultee XB-46 Bomber rides high and fast on four J-35 Turbojet engines equipped with SKF Ball and Roller Bearings.

This is another of the interesting and imaginative assignments that are solved at the desks and drawing boards of SKF Engineers. SKF Industries, Inc., Philadelphia 32, Pa. 6737

Industrial Ball and Roller Bearings Engineered by SKF

If you can't afford television, build this:

(From page 11)



LIGHTS

A	Red	7.5	watts
B	Blue	10	"
C	Green	15	"
D	Yellow	15	"
1	Green	"	"
2	Blue	"	"
3	Red	"	"

Schematic Diagram of Color Organ

Kodak

Because photography is accurate to the last detail

The magic of photography turns hours of costly drafting room time into a minute-quick job of utmost accuracy.

Correcting an engineering drawing—or restoring a dimmed one—used to take long, tiresome hours. But not today. For photography with its ability to record detail in a flick of time has been put to work, and the most intricate drawing is copied accurately, inexpensively, and with lasting quality.

Using the new Kodagraph Autopositive Paper, you can get sharp positive prints directly from originals of every type, even from worn or weak tracings—get them with regular blueprint or direct process equipment—in ordinary roomlight, without negatives.

Using the new Kodagraph Contact Paper (with conventional photo-copying equipment and negative step) you can produce sharp, clear legible photographic prints of letters, specification sheets, forms, drawings.

Using the new Kodagraph Projection Papers, you can enlarge small-scale negatives of drawings and documents to original size or larger . . . get high contrast reproductions.

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This same ability to reproduce detail exactly, completely, lastingly . . . even to improve its quality . . . gives photography a multitude of uses in your plant. It can help make your designs faster, your production methods smoother, and get your product to the dealer's sooner.

Eastman Kodak Co., Rochester 4, N. Y.

Advancing industrial technics—Functional Photography

How Edwin Peterson might answer his 7-year-old son Paul. Edwin knows the answers. He's been around Norton for 30 years. In fact, ten percent of Norton employees have been on the job 25 years or more.
GM
TRAIN OF TOMORROW

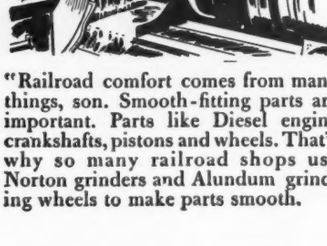
"GEE, DAD, WHY DOES IT HAVE AN UPSTAIRS?"

"To make traveling more fun. The idea is to give people more to see and do while riding faster and safer. That means more passengers for the railroads so that they can keep fares down and still add more comfort to long trips."

"Railroad comfort comes from many things, son. Smooth-fitting parts are important. Parts like Diesel engine crankshafts, pistons and wheels. That's why so many railroad shops use Norton grinders and Alundum grinding wheels to make parts smooth.

"Take those side rods on steam locomotives. They get farther over on the smooth side thanks to Norton internal grinding wheels. And parts are finished so accurately with Norton quality controlled wheels that they last for thousands of miles, Paul.

"Getting back to comfort . . . modern trains travel over 60 miles an hour. So, they need smooth rail joints. Those joints are welded for safety. Then, they're ground smooth and slotted with Norton grinding and cut-off wheels."



"Hundreds of other parts of modern railroad trains and tracks also get a lift from the sure touch of Norton Products. So does just about any other product you can name. That's why I'm not boasting when I say that Norton makes better products to make other products better."

NORTON

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NORTON COMPANY, WORCESTER 6, MASSACHUSETTS

RCA scientists develop new *direct-reading* Loran instrument which simplifies problems of navigation.

The **homing pigeon** *goes to sea*

Now science gives the navigator an improved "homing pigeon instinct," a way by which—without checking sun or stars—he can head his ship directly home.

Already thoroughly proved, *Loran equipment* has been simplified through RCA research and engineering, so that almost anyone can learn to use it in a few minutes. Free of human error, readings appear *directly* on the instrument. A quick check gives position.

Brain of this Loran system is a circuit developed at RCA Laboratories which splits seconds into millions of parts—and accurately measures the difference in the time it takes a pair of radio signals to travel from shore to ship.

Given this information, the navigator, hundreds of miles from shore, can determine his position quickly and accurately. Loran's simplicity adapts it to every type of vessel from merchant ship to yacht. Manufactured by Radiomarine Corporation of America, a service of RCA, it is already being installed in U. S. Coast Guard rescue ships.

The meaning of RCA research

RCA's contribution to the development of this new direct-reading Loran is another example of the continued leadership in science and engineering which adds *value beyond price to* any product or service of RCA.

* * *

The newest advances in television, radio, and electronics can be seen in action at RCA Exhibition Hall, 36 West 49 St., N. Y. Admission is free. Radio Corporation of America, RCA Building, Radio City, N. Y. 20.

Continue your education with pay—at RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short wave and FM circuits, television, and phonograph combinations).
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Write today to National Recruiting Division, RCA Victor, Camden, New Jersey.

Also many opportunities for Mechanical and Chemical Engineers and Physicists.

RCA **RADIO CORPORATION of AMERICA**

World Leader in Radio—First in Television

NE has everything

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National Electric has a *complete* line of wires, cable, conduit, raceways and fittings for every wiring need.

Just remember—when you get in a spot where you need something *good* (electrically speaking) but fast—the wholesaler who handles National Electric products is your safest bet.

NATIONAL ELECTRIC PRODUCTS WIRING SYSTEMS

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A BROAD LINE OF QUALITY CUTTERS
for efficient milling

There are styles and sizes of Brown & Sharpe Cutters to meet a wide variety of milling requirements. Superior design, materials and heat treatment give them maximum cutter life and assure lowest cost in the long run. Specify Brown & Sharpe Cutters.

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music on the power lines

(*Continued from page 7*)

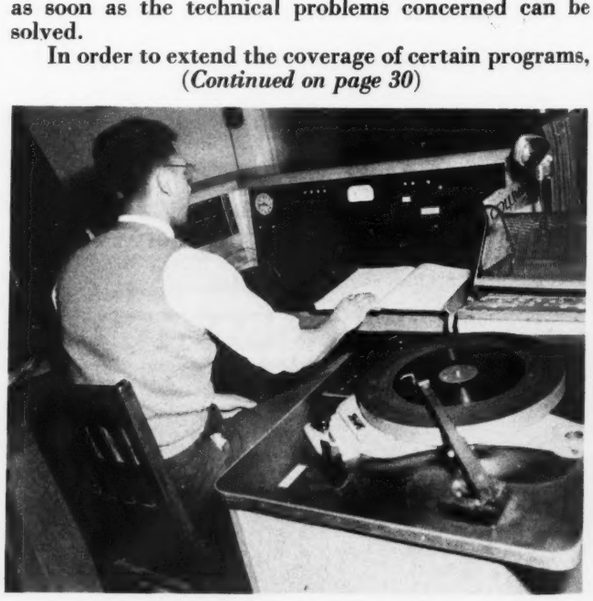
college stations do, makes it possible to have complete fulfillment of the special requirements of each installation as the station adds studios, rather than a compromise standard control console. The studio equipment is designed so that the turntables can be in either the studio or the control room, depending on the requirements of the program. In addition, in order to have the advantages of the Columbia Long Playing recordings, and in keeping with our program of high-fidelity reproduction, one of the turntables has been equipped with provision for the L.P. records. General Electric variable reluctance pick-up cartridges are used throughout, with REK-O-KUT transcription turntables.

About a year ago, the station obtained several spools of ten-pair cable, and the permission to run cables throughout the M. I. T. steam tunnel system. At present, cables have been run throughout most of the Institute, so that remote broadcasts are possible, on short notice, from any point in Walker Memorial building, Room 10–250, and any point in the main building. The station has been fortunate in having the cooperation of the Communications Laboratory to the extent of lending the necessary equipment for remote broadcasts. Plans for the future include the construction of a remote amplifier more suited to the specialized needs of WMIT, patterned after commercial equipment, with the addition of built-in equipment for communication with the studio during broadcast. It is also intended to run cables to the new library for broadcasts from there, and to Briggs field house, to pick up the games.

At present, programs can be heard in the Dormitories, the Barracks, and the Graduate House. A cable has already been laid to the new dormitory, so that WMIT will feed programs there as soon as the amplifiers are ready. In addition, as soon as Eastgate is finished, its residents will be able to receive the station, according to present plans. Sometime in the near future, a transmission line will be run to the Infirmary and to Westgate, as soon as the technical problems concerned can be solved.

In order to extend the coverage of certain programs,

(*Continued on page 30*)



The engineer at the new console studies the program format as music goes out over the air.

THE DU PONT DIGEST

FOR STUDENTS OF SCIENCE AND ENGINEERING

Research across the U. S. A.

YOUNG SCIENTISTS ARE BUILDING CAREERS WITH DU PONT FROM CONNECTICUT TO TEXAS

When you think of Du Pont research, you may think first of Wilmington, Delaware. Actually, only eight of the Company's 36 research groups are located there. Du Pont scientists now pursue their studies in 11 states scattered from Connecticut to Texas.

Each of these laboratories is a self-contained operation. It may be devoted in part to fundamental research and applied research, or to investigations looking to the development of new products—sometimes a combination of these activities.

An unusual Du Pont laboratory is one opened last year at Newburgh, New York.

Inside the Laboratory

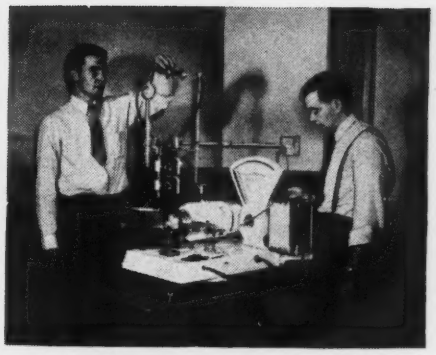
In the three-story building at Newburgh, scientists have at their disposal the most modern equipment for study of coated fabrics and plastic sheetings under all sorts of conditions. For example, a new product can be tested in a room maintained at a temperature of −20° F. In other rooms, the effects of high temperature and humidity can be studied. Equipment is available for testing tensile strength, tear resistance, fading, flex and flame resistance, and many other characteristics. One of Du Pont's 33 libraries has quarters in the building; there is a photographic darkroom, as well as offices, conference and work rooms.

The Newburgh Laboratory works closely with the adjacent plant, which makes "Fabrikoid" pyroxylin coated fabrics, "Fabrilite" vinyl resin coated fabrics and plastic sheetings, "Tontine" washable window shade cloth, bookbinding materials, and other coated and impregnated fabrics and plastic sheetings for many uses.

Research at Du Pont

Research has long been a major activity at Du Pont, and it flourishes in an atmosphere of appreciation, encouragement and patience. The new products, the new plants, and the new and better jobs of the years to come will develop from the painstaking research programs being carried on today in the laboratories.

Newest Du Pont laboratory, *at Newburgh, N.Y., was opened last year. It is devoted to research and development work in the field of coated and impregnated fabrics and allied products.*



H. A. Van Etten, *B. S. Ch., Colgate '42, and E. R. Grisé, M. S. Ch., Worcester Polytechnic Institute '48, investigating the properties of vinyl compounds used in plastic-coated fabrics.*

K. F. Richards, *B. S. Ch. E., Cornell '48, and E. K. Holden, M. S. Ch. E., Delaware '48, studying "Teflon" tetrafluoroethylene resin insulating material with special apparatus at the Newburgh Laboratory.*

Choice of Careers

Each of the Du Pont manufacturing departments conducts continuous research. They operate much like separate companies, with interests ranging from heavy chemicals to plastics and textile fibers. Each holds challenging opportunities for college-trained chemists and physicists, as well as chemical, civil, electrical, industrial and mechanical engineers, also those specializing in production, sales and many other fields.

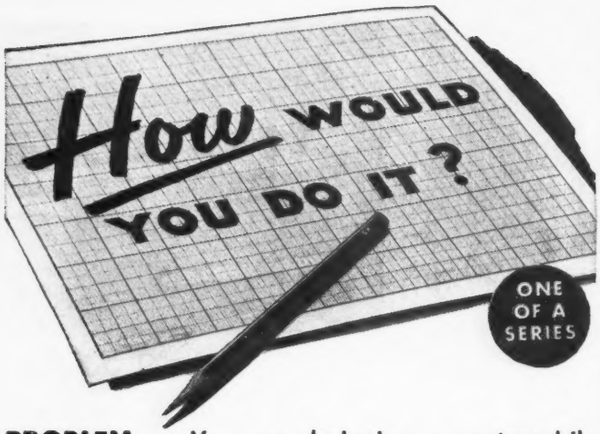
In this alert, ever-growing organization, young graduates can choose from a variety of careers the one that suits them best as their ability and interests develop.

DU PONT

REG. U. S. PAT. OFF.

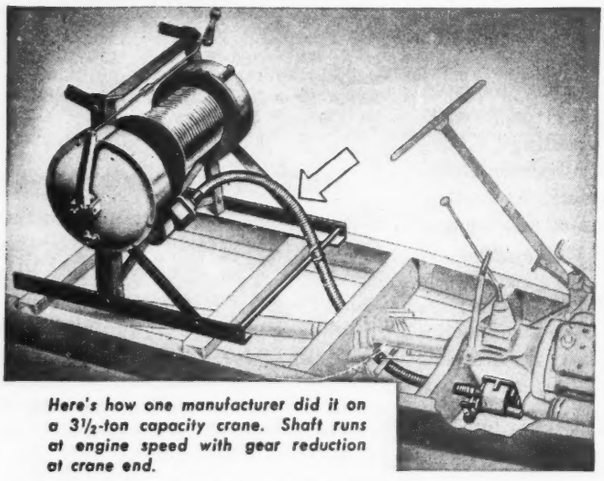
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

Entertaining, informative—Listen to "Cavalcade of America" Tuesday Nights, NBC Coast to Coast



PROBLEM — You are designing an automobile service car with a crane on the back end. You are going to take power from the transmission to drive the crane drum. How would you do it?

THE SIMPLE SOLUTION — Use an S.S.White power drive flexible shaft. Connect one end to a take-off on the transmission and the other end to the clutch which operates the crane drum—simple, easy to install, good for positive, dependable operation.



Here's how one manufacturer did it on a 3½-ton capacity crane. Shaft runs at engine speed with gear reduction at crane end.

This is just one of hundreds of remote control and power drive problems to which S.S.White flexible shafts provide a simple answer. Engineers will find it helpful to be familiar with the range and scope of these useful "Metal Muscles"* for mechanical bodies.

*Trademark Reg. U. S. Pat. Off. and elsewhere

WRITE FOR BULLETIN 4501

It gives essential facts and engineering data about flexible shafts and their application. A copy is yours for the asking. Write today.

S.S.WHITE INDUSTRIAL DIVISION

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FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
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One of America's AAAA Industrial Enterprises

making construction materials work

(*Continued from page 13*)

forces due to wind or earth tremors, numbers of steel diagonals are incorporated throughout the building to force it to act like a truss, instead of like the collapsible criss-cross partition in an egg-box. Steel panelling would act like the stressed skin of the airplane, each panel rigidly connected to at least four main members of the steel frame, thereby preventing the relative movement of any member or the rotation of any joint. Every exterior member of the building would be braced in this way, everywhere along both its edges, except where windows occur. This would be stronger than the present truss system, and a much more logical type of "atom-bomb proofing" than rigidly attaching thousands of tons of stone.

A common objection that might be raised to the use of steel panels would be that they would not be as much protection against the elements as the stone we now use. Actually, quite the reverse would be found to be true. Stone, with its many pores, its mortar joints, and its expansion joints, is notoriously leaky. For centuries men have tried to develop methods of flashing which would keep the water out, but walls still leak despite it all. One may remember reading about the trouble experienced several years ago in the Empire State Building. The inside of an exterior wall suddenly seemed to explode, on one of the upper stories, and a virtual flood engulfed much of that floor. A rush call immediately went to the master plumber of the building to find the burst pipe, but it turned out to be no pipe at all. Instead, water had leaked inside the stone facing, and had built up a head of about forty feet before it burst through the plaster into the room. Such a leak is rare, of course, but leakage is common, and is the principal cause of stains on the stonework. Steel would be much more dependable in this respect. It would be easier to waterproof where joined, and, of course, has no porosity at all. Expansion joints are still necessary, since sway and differential expansion of the building must be provided for no less than with stone on the outside, but so are expansion joints required on a steel railway car, and the joint is made watertight.

But the objection might be more valid when applied to the insulating qualities of steel as compared with stone. Stone, of course, has a low thermal conductivity, and is also a poor radiator of heat, thus helping to maintain an even temperature within the building. Metal, on the other hand, would be much the reverse in both respects, except that radiation could be cut down by the use of the proper paint or other facing for the metal. But the panel can be insulated with any one of many materials whose qualities are better than those of stone, and yet weigh only about one per cent as much. By insulating our panels, builders are again making their materials work, and they will work well.

In addition, this can be carried one step further. There can be installed a second metal panel on the inside faces of the column, about a foot inside the first insulated one. The space between these panels can be kept open all around the building from bottom to top, except at windows, whose sashes can also be insulated. Then, with the aid of similar openings in the interior of the building, and connected to hot air ducts in the basement, this can constitute practically the entire heating system for the building. Thus the additional weight and expense of all the customary heating pipes and radiators in a building would be saved, representing another estimated eight or ten per cent of total cost.

(*Continued on page 34*)

Engineers review design of a new petroleum project. E. R. Wilkinson, L. S. U. '34; O. R. Menton, L. S. U. '38; W. A. Whitaker, Virginia '25; H. C. Leak, Mississippi State '43.

They're mighty good men to have around...

In times like these, engineers like the four shown here are mighty good men to have on the job at Esso Standard Oil – where our 28,000 workers today *average* 12 years of service with the company.

Their extra measure of skill, experience and job loyalty has set amazing records in *production* to help meet the high demand for gasoline and heating oil and other products.

One reason these extra-good workers are here today is simply the extra-good jobs they have at Esso Standard.

Over 30 years ago, the company set up an unusual "good jobs policy." It was based on the belief that better jobs would mean better workers, and that would mean a better company.

Since then, with our workers, we have developed plans which give every Esso Standard worker such job advantages as these: ***uniformly good wage scales... vacations with pay... special benefits in case of sickness or accidents... chance to advance in the company... cash savings in a Thrift Plan... fair treatment at all job levels... and planned retirement with steady income assured for life.***

All this was done as a matter of good business. It has given good business results. Not a strike or major work disturbance in over 30 years. Steady, skilful workers on the job. The development of new products from petroleum. New records in production to meet the country's needs. Yes...they're mighty good men to have around.

Esso

ESSO STANDARD OIL COMPANY

One-Question Exam On FASTENING

Q. Does it cost more to buy or use fasteners?

A. It's the cost of using a fastener that counts, not the initial purchase price. So the man with the responsibility of buying or specifying fasteners should make sure that *every* function involved in the *use* of bolts, nuts, screws, rivets and other fasteners contributes to the desired fastening result—maximum holding power at the lowest possible *total* cost for fastening.

YOU GET TRUE FASTENER ECONOMY WHEN YOU CUT COSTS THESE WAYS

1. Reduce assembly time with accurate, uniform fasteners
2. Make satisfied workers by making assembly work easier
3. Save receiving inspection through supplier's quality control
4. Design assemblies for fewer, stronger fasteners
5. Purchase maximum holding power per dollar of initial cost
6. Lower inventory by standardizing types and sizes of fasteners
7. Simplify purchasing by using one supplier's complete line
8. Improve your product with a quality fastener

104 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

R B & W
THE COMPLETE QUALITY LINE

Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, California

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

A "FOUL WEATHER" FRIEND TO CABLE USERS

Every kind of weather but fair is manufactured in this Weatherometer which is used regularly in testing sections of Okonite Cable. For example, repeated cycles of water spray and ultra violet light are combined with freezing in a refrigerator. The result: a rapid succession of violently contrasting effects which tests the cable more drastically than could years of actual exposure.

This is one of a series of continuing tests in which Okonite puts modern equipment and engineering personnel to work pre-testing and establishing the life expectancy of its electrical wires and cables. The Okonite Company, Passaic, N. J.

OKONITE SINCE 1878 5169
insulated wires and cables

music on the power lines

(*Continued from page 26*)

and to make it possible to broadcast programs from the other Boston college stations, a network has been planned tentatively for some time in the not too distant future. This network would consist of leased telephone lines, with WMIT as the key, or switching, station. In order to determine how well this would work, a trial hook-up with WHRV, the Harvard station, is in the planning stage now.

If the proposed network becomes a reality, it will greatly increase the program variety possible on all of the Boston college radio stations. Harvard with its forums and special features, Emerson with its radio drama productions, Tech with its programs like the midnight classical music shows and the Nite Owl — a combination of these special programs, together with the regular WMIT programs will provide a full program of entertainment and information especially suited to the desires of a student audience, that will seriously compete with the commercial stations for the spare time of the students of M. I. T. It is the desire of the station, and the focal point of all its projects, to some day be able to present all of this to all the students of the Institute, whether they live on the campus, in fraternities, or in student apartment houses off the campus.

"Is this the same ROEBLING that helped you build the Golden Gate Bridge?"

"Well, Ted, that's one way to put it! And this sure is the same Roebling. Besides making wire and huge cables for suspension bridges, Roebling weaves wire screens. I've seen screens like this in quarries and mines all over the country."

☆ ☆ ☆

The fact is, its Bridge Division is only one of Roebling's seven major divisions, each producing a distinctive line of wire or wire products of wide and essential service in industry. Importantly too, at the big Roebling plants in and near Trenton, New Jersey, developments are made constantly that bring new efficiency and economy to a vast range of industrial operations.

WIRE ROPE. Roebling wire rope is made in a large range of types to assure topflight performance in every application. Roebling Preformed "Blue Center" Wire Rope is unsurpassed for ease of handling, smooth operation and long life.

ELECTRICAL WIRE—CABLE—MAGNET WIRE. Roebling makes more than 60 standard types of electrical wire and cable—meets practically every transmission, distribution and service requirement. Roevar Magnet Wire is a leading specification for high-speed winding.

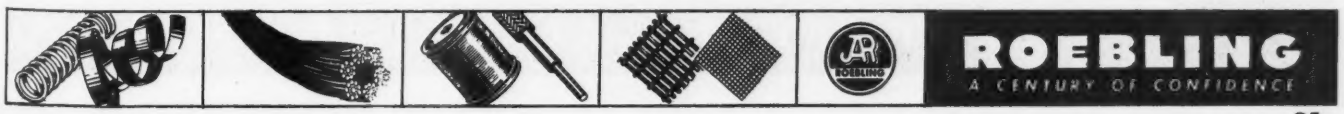
WOVEN WIRE FABRIC. From the largest, most rugged Aggregate Screens to the most finely woven Filter Cloths, there's a full line of Roebling industrial screens. Wires made of special steels and non-ferrous metals assure longer wear and corrosion resistance.

ROUND—FLAT—SHAPED—WIRE. Roebling high carbon wire is a quality product and dependably uniform in gauge, grain structure and finish. This, of course, means that machine stoppages and rejects are cut to a minimum, and production costs pulled down.

☆ ☆ ☆

Whatever career you are studying for, when you get on the job you will find one or more types of Roebling products serving there, dependably and at low cost. John A. Roebling's Sons Company, Trenton 2, New Jersey.

BRANCH OFFICES: *Atlanta,* 934 Avon Ave. ★ *Boston,* 51 Sleeper St. ★ *Chicago,* 5525 W. Roosevelt Rd. ★ *Cleveland,* 701 St. Clair Ave., N. E. ★ *Denver,* 1635 17th St. ★ *Houston,* 6216 Navigation Blvd. ★ *Los Angeles,* 216 S. Alameda St. ★ *New York,* 19 Rector St. ★ *Philadelphia,* 12 S. 12th St. ★ *Pittsburgh,* 855 W. North Ave. ★ *Portland, Ore.,* 1032 N. W. 14th Ave. ★ *San Francisco,* 1740 17th St. ★ *Seattle,* 900 First Ave. So.



MARKING ITS GOLDEN ANNIVERSARY, COLUMBIA SALUTES THE GREAT INDUSTRIES IT SERVES

The past fifty years constitute an era for American industry which is without parallel in the history of the world. Industrial technical progress and physical expansion have helped to save the nation in two great wars . . . and have enabled its people to enjoy great benefits that should be a constant reminder of the value of the free enterprise system through which these advantages have been obtained.

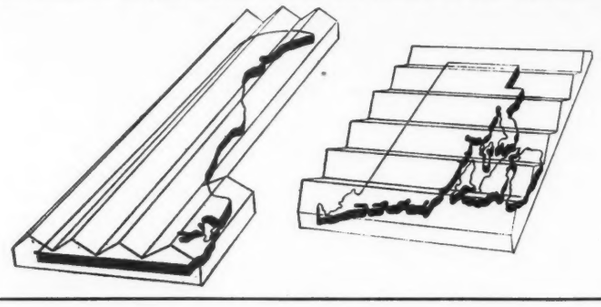
Columbia is proud of its fifty years of service to so many of the great basic industries of the nation. It looks forward to keeping pace with the new progress which these industries are now beginning. Pittsburgh Plate Glass Co., Columbia Chemical Division, Fifth at Bellefield, Pittsburgh 13, Pa.

MILLIONS OF TONS OF ALKALIES FOR ALUMINUM • CHEMICALS • DRUGS • EXPLOSIVES • FOODS • GLASS • PETROLEUM • PLASTICS • PULP AND PAPER • RAYON • RUBBER • SOAP • STEEL • TEXTILES

Since 1899, when its first plant began operations at Barberton, Ohio, Columbia has produced vast quantities of alkalies and related products which, at some stage, have entered into the production of almost every product essential to modern living.

50 Years of Service to the Nation's Basic Industries

Greenhouses for Delaware and Rhode Island! Columbia's production of Soda Ash alone, if used solely in the making of window glass, would produce enough to more than cover the total land and water areas of both Delaware and Rhode Island!



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PAINT · GLASS · CHEMICALS · BRUSHES · PLASTICS

PITTSBURGH PLATE GLASS COMPANY

50th birthday of the company whose products you know by the trade-mark: TIMKEN

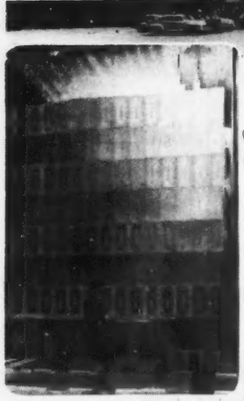
SINCE 1899 THE TIMKEN ROLLER BEARING COMPANY HAS BEEN HELPING AMERICAN INDUSTRY GET THE MOST FOR ITS MONEY

NOBODY likes to buy a "pig in a poke". In America you don't have to. You're protected by trade-marks like "TIMKEN".

Registered as a trade-mark in the United States Patent Office, "TIMKEN" identifies products made by The Timken Roller Bearing Company: Timken tapered roller bearings, Timken alloy steels and seamless tubing and Timken removable rock bits.

Experience over the years has shown Timken products to be the finest in their respective fields. And many thousands of men and women are working hard to keep them that way. No wonder it has become a habit throughout industry to look for the trade-mark "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The Modern Uni-Pull Drive
UNIFORM PULL AROUND THE PULLEY
Modern Flat Leather Belt
UNIFORM PULL ACROSS THE PULLEY
Tension-Controlling Motor Base
LEATHER PLUS PROPER TENSION Gives Continuous, Dependable Service
An ordinary trouser's belt is an everyday reminder of the continuous, trouble-free service leather plus proper tension can give.
Modern power transmission uses these same two ingredients in the Uni-Pull drive. Uni-Pull teams a modern flat leather belt with a tension-controlling motor base and gives today's industry a flexible, compact, long service drive . . . a drive that makes the most of the inherent power-carrying advantages of leather.
American LEATHER BELTING Association
Headquarters for Authentic Power Transmission Data
41 PARK ROW, NEW YORK 7, NEW YORK
AL 43



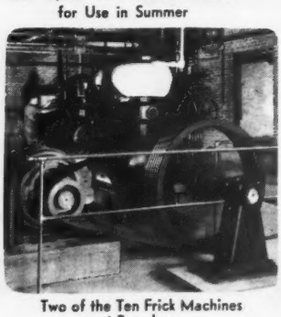
Ice—2,000 Tons of It—Stored for Use in Summer

Another COMMUNITY REFRIGERATION CENTER Succeeds with Frick Refrigeration

The Mutual Cold Storage Cooperative, located between Broadway and Timberville, Va., serves the prosperous Shenandoah Valley in many ways: makes 50 tons of ice daily, stores 2,000 tons, ices trucks and railway cars, operates several ice routes; quick-freezes 50,000 pounds of poultry per day; stores 375,000 bushels of apples and 1½ million pounds of frozen foods; processes fresh foods, rents 1,285 lockers; and provides cooling services to three large cooperatives—for fruit, poultry and meats—nearby.

For nearly 20 years the Mutual plant has used Frick Refrigeration, now has 10 Frick machines. Any community—YOUR community—could profit from a similar Refrigeration Center. Let us give you details: write

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, is approved under the G. I Bill of Rights.



Two of the Ten Frick Machines at Broadway

DEPENDABLE REFRIGERATION SINCE 1883
FRICK CO.
WAYNESBORO, PENNA. U.S.A.

Also Builders of Power Farming and Sawmill Machinery

low speed aerodynamics

(*Continued from page 17*)

expectations, the increased resistance to phugoid of the gas model enabled maximum lift to be passed and a genuine stall resulted from which recovery was positive.

Of course, stability problems are encountered only in aircraft, but the new airfoils may be used to advantage elsewhere. Electric fans, windmills, air-conditioning systems, and duct vanes could all benefit from the increased deflection of air for a given power which is the aim of special low speed airfoils.

making construction materials work

(*Continued from page 28*)

The final objection which might be raised, and is even now, is that of outside appearance. Stone has been on the outside of buildings for so long that it has conditioned aesthetic tastes. But there is no other reason why metal could not do as much aesthetically for a building as can stone. Design could be printed into it, and colors enameled on. Work is being done in developing adhesives which would hold on an additional thin facing of plastic, or even real or artificial stone, if the old appearance of a bearing wall must be preserved.

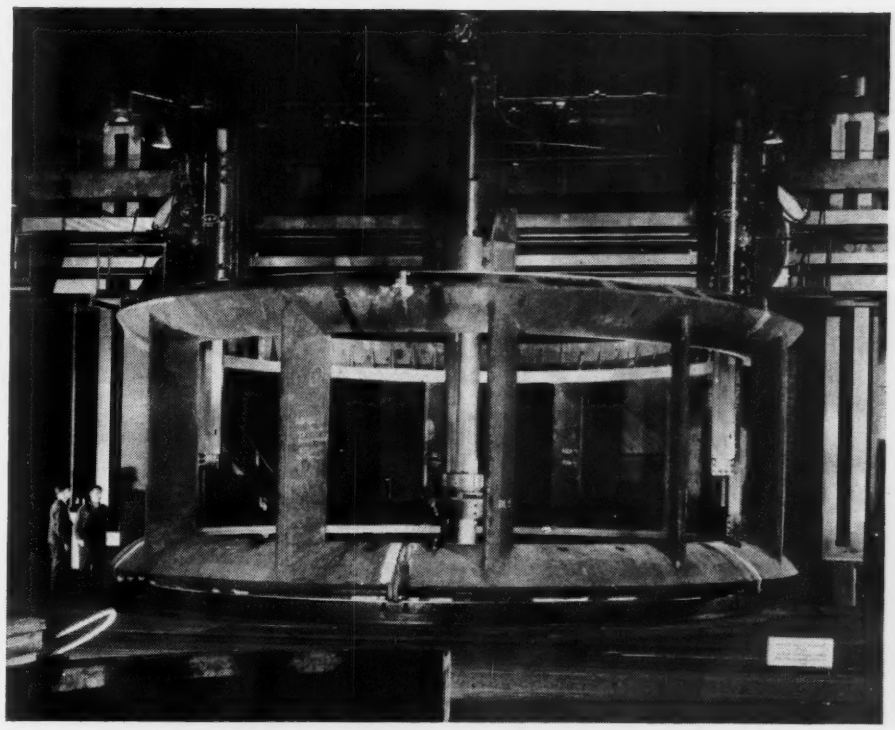
Metal panelling now seems sure to be well on its way to replacing stone as the facing for tomorrow's buildings. As long as stone worked, it was worth using. There is nothing to be gained by continuing to apply stone only to satisfy an outdated aesthetic taste, when it necessitates much more labor expense, and a much heavier steel framework to support it, and when it can do nothing as well as insulated metal panels can.

BUILD the basic machines of an industrial world!

by CARL MALMBERG
Superintendent, Tank and Plate Shop
ALLIS-CHALMERS MANUFACTURING CO.
WEST ALLIS WORKS
(*Graduate Training Course—1930*)

PRODUCTION METHODS have become a good deal more technical and complicated in the last few years. There is a big difference between the way we do things now and the way we did them when I left the Allis-Chalmers Graduate Training Course to work in the machine shop in 1930. That is why there are more and more opportunities in the manufacturing end of the business for young engineers who get a thrill from watching a project grow from a roll of blueprints to a big electric power installation or machinery for a giant processing plant.

CARL MALMBERG



Machining speed ring for a 55,000 hp turbine on a 40' boring mill, one of the largest in the country. Many A-C machines and methods are unique because of the tremendous size of work pieces and wide variety of operations required in building the world's greatest range of industrial equipment.

Close Coordination

In my section of the shop we specialize in fabricating machines and parts from sheet and plate steel. We work closely with the design engineers to develop the most economical way of producing their designs and we do much designing on our own. We work closely with every other manufacturing department, because more and more Allis-Chalmers products are being designed to replace cast members with welded members, and in my work we do the welding for the whole plant.

Welding stator yoke on 38,889 kva hydraulic turbine-driven generator.

One recent interesting project was the fabrication of stainless steel buckets for impulse-type hydraulic turbines to replace the old cast-type buckets. Working with design engineers and hydraulic engineers, our tank and plate specialists developed a design and method of manufacturing that produced buckets with several times the life of the old type.

Opportunities Everywhere

New developments in every department mean almost endless opportunities for young engineers. Right now, the erection shop is building a big crusher for processing taconite in the Mesabi range, and we are supplying most of the other ore processing equipment for this gigantic plant, too. At our Norwood plant, engineers have completely rebuilt the production system on motors and small pumps for greater efficiency and lower costs.

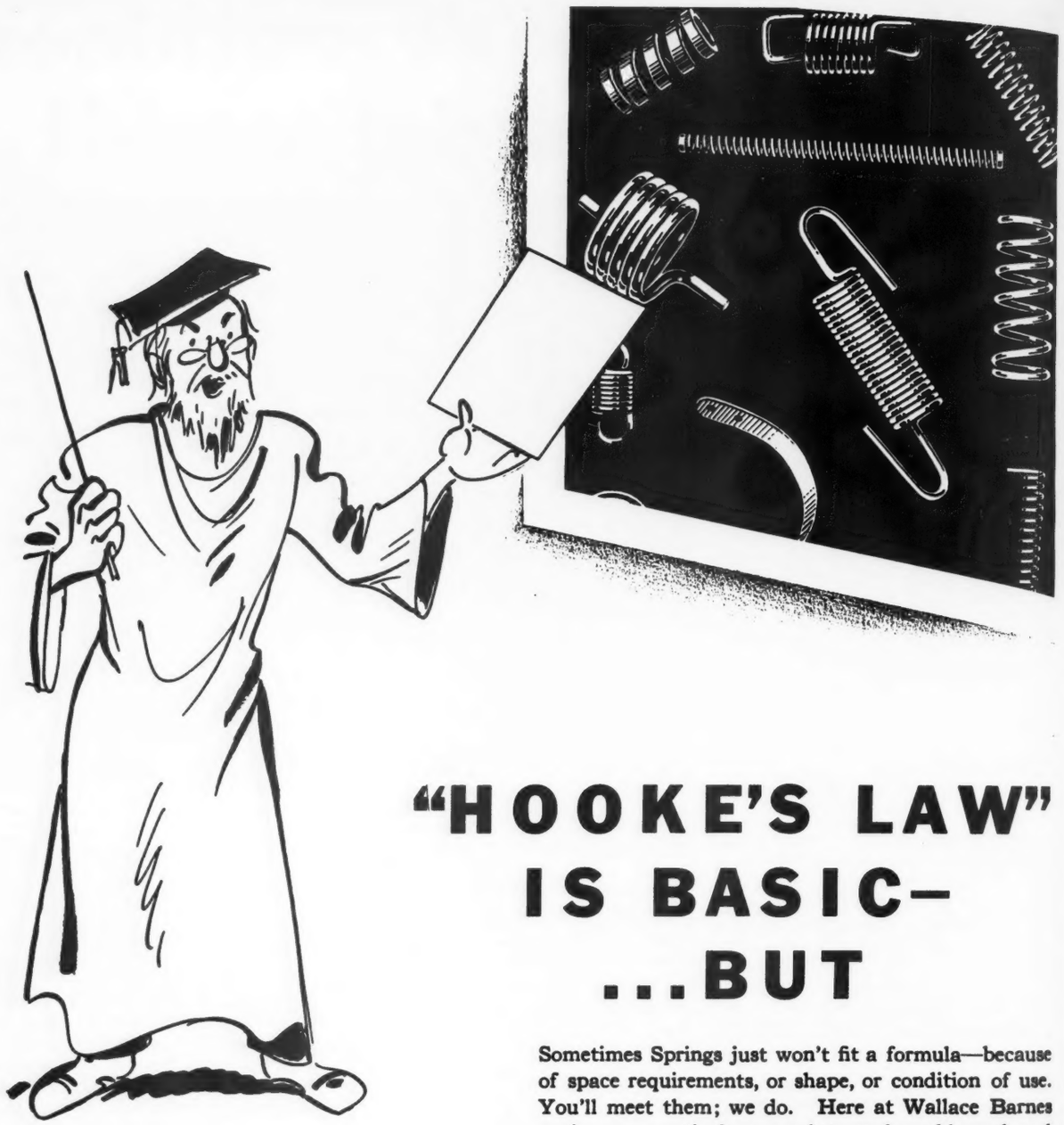
In fact, here at Allis-Chalmers there are big opportunities for young engineers in all phases of engineering work—design, research and development, manufacturing, sales and erection—in nearly any industry you can name. For Allis-Chalmers builds primary equipment for electric power . . . mining and ore processing . . . pulp and wood products . . . flour milling . . . steel . . . agriculture . . . public works . . . for *every* basic industry.

The thing that influenced me most when I left the University of Illinois to join Allis-Chalmers, was the tremendous breadth of opportunity. Some of my friends from that GTC class of 1930 are sales engineers now, some are design engineers, some have traveled around the world with erection crews. I chose manufacturing because I like to see things take shape before my eyes. I tried a good many things before I made my choice and my choice has been good.

Write for details of the Allis-Chalmers Graduate Training Course—requirements, salary, advantages. Representatives may visit your school. Watch for date.

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

ALLIS-CHALMERS



"HOOKE'S LAW" IS BASIC— ...BUT

Sometimes Springs just won't fit a formula—because of space requirements, or shape, or condition of use. You'll meet them; we do. Here at Wallace Barnes we have a practical approach to such problems, based on experienced and specialized skill that should be helpful. Let us show you sometime how this engineering and production service can relieve you of many spring design problems in your chosen field.

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SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

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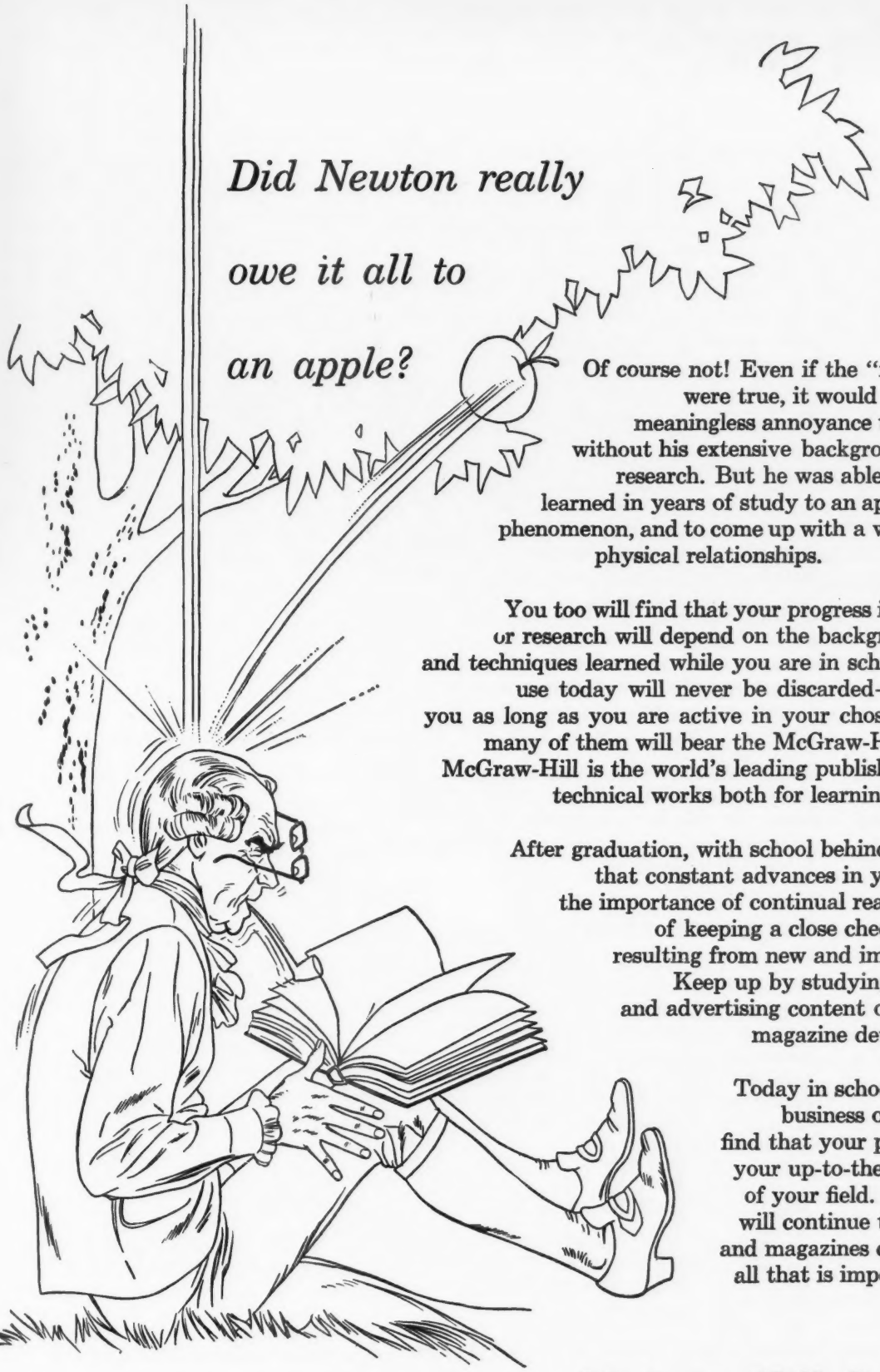

Did Newton really owe it all to an apple?

Of course not! Even if the "falling apple" myth were true, it would have merely been a meaningless annoyance to Sir Isaac Newton without his extensive background of reading and research. But he was able to apply principles learned in years of study to an apparently accidental phenomenon, and to come up with a whole new theory of physical relationships.

You too will find that your progress in business, practice or research will depend on the background of knowledge and techniques learned while you are in school. The books you use today will never be discarded—they will go with you as long as you are active in your chosen field. Of course, many of them will bear the McGraw-Hill imprint because McGraw-Hill is the world's leading publisher of scientific and technical works both for learning and for reference.

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HEADQUARTERS FOR TECHNICAL INFORMATION

330 West 42nd Street, New York 18, New York

briefing the news

Transistor Tetrodes . . .

The now familiar transistor is rapidly maturing into competition for the vacuum tube in fields where the latter formerly held supremacy. It was recently announced that the germanium crystal amplifiers (*T. E. N.*, November, '48) have been developed in the form of tetrodes which provide a high degree of isolation between signals in mixer service.

Color Standards . . .

Since 1931 certain standards have been in use for the interpretation of spectrophotometric data which are the backbone of modern colorimetry. These standards, known as the standard observer, enable colors to be measured and defined and later reproduced easily and accurately. Recently interest has been aroused by reports that the internationally accepted standard observer is not adaptable to the colorimetry of certain titanium pigments. It was found that two visually distinguishable colors could be produced by mixtures of these pigments, but spectrophotometric data, interpreted by the observer, indicated these colors to be the same. It has been suggested that the observer weighs too lightly the spectrum below 430 millimicrons.

Pure Iron Magnets . . .

Pure iron can be permanently magnetized if it is in the form of ultra-fine particles. When iron formate is carefully decomposed, there can be obtained iron powder with a particle size of less than one-fifth micron. This material, when compressed with a binder and magnetized, is said to "compare well with average grades of Alnico."

More Tracers . . .

High-speed electrons from radioactive strontium-90 are used in a beta-ray thickness gauge to measure the thickness of sheet materials moving along conveyors. The number of beta particles coming through the material being checked gives indication of variations in thickness. Since the gauge does not touch the object measured, it can check thickness for paper, plastics, and rubber without causing damage.

Argon Replaces Acid . . .

A new metal etching process has been developed for industrial use in determining the structure of metal surfaces. The new method lays bare the crystalline structure of metals by bombardment with ionized atoms.

The metal sample to be etched is placed in a partial vacuum with argon, at one end of a 12,000 volt potential difference. Argon ions strike the metal surface and knock off minute particles of metal. Comparison of the crystalline patterns produced by ion bombardment with those produced by the best chemical etching methods show that the former brings out the structure with more clarity.

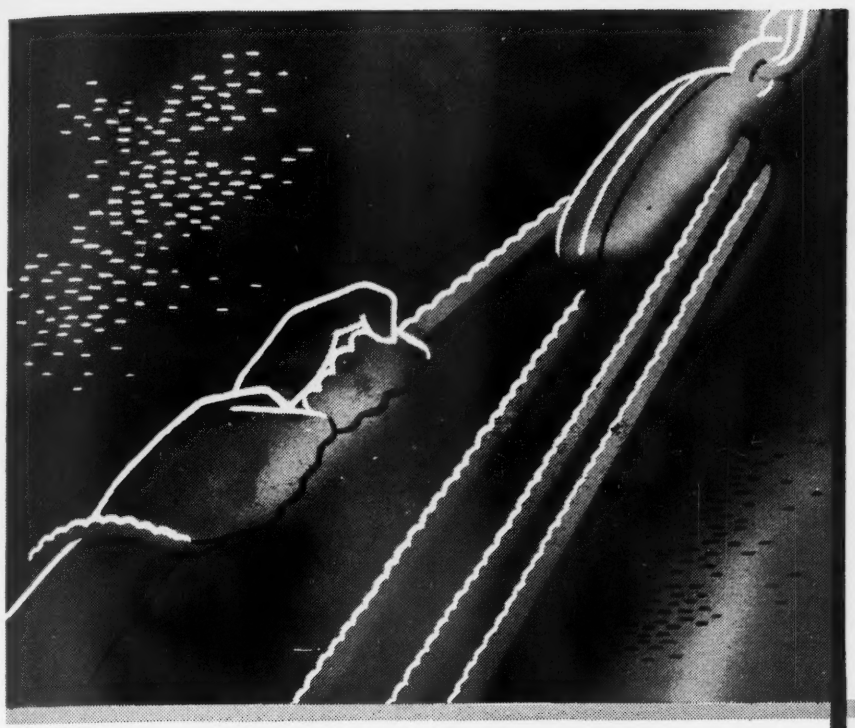
Dope . . .

Anyone familiar with model airplanes knows of the high flammability of the cellulose nitrate, acetate or butyrate dope used to make taut the fabric covering of the plane. This flammability in the case of full-sized planes has been the cause of much damage to life and property. No other substances, however, are known which will make taut the fabrics as effectively or permanently as the cellulose dopes. The addition of fire-retardant substances to the dopes lessens their capacity to tauten and efforts have been therefore made to produce fire-retardant coatings to be applied to the already doped surface.

Tests on standard fire-retarding substances show that it is possible to double the time for fabric destruction by fire. Those coatings which appear most promising contain considerable organically combined chlorine which, on pyrolysis, produce hydrogen chloride gas. Certain pigments were also found to be effective in the Bureau of Standards tests in the field.

Anesthesia . . .

A report delivered at this summer's convention of the American Medical Association reveals one more example of electrical plotting of body processes. Electrical records of the activity of the brain and heart now can give an anesthetist warning of danger to a patient on the operating table about two minutes before such signs show up in pulse and breathing rates, the two commonly observed quantities. When regular electrical brain waves flatten out, it is time to turn on the oxygen supply to the patient. Preliminary results show the technique to be useful with any type of anesthetic.



When sail trimming is required

No business can stay healthy without an occasional overhaul of its production set-up—particularly when a seller's market begins to quiver.

Molybdenum steels may be just what the doctor ordered to reduce production costs, and still maintain the product's reputation for consistent performance.

Send for our comprehensive 400-page book, free; "MOLYBDENUM: STEELS, IRONS, ALLOYS."

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS

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So you're going to be an engineer
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from coal to coke

(*Continued from page 9*)

Detailed description of the many methods of effecting heat transfer in the coke oven is out of the question; a few generalizations and significant differences will suffice. All systems of utilizing the heat of waste gas employ a reversing procedure involving at least two sets of flues and regenerators. Reversal occurs so that gas may be preheated in one set of regenerators and burned in the corresponding set of flues, while the waste gas is passing through the other set of flues and giving up its sensible heat to the regenerators serving those flues. Periods between reversals vary, but often range around thirty minutes.

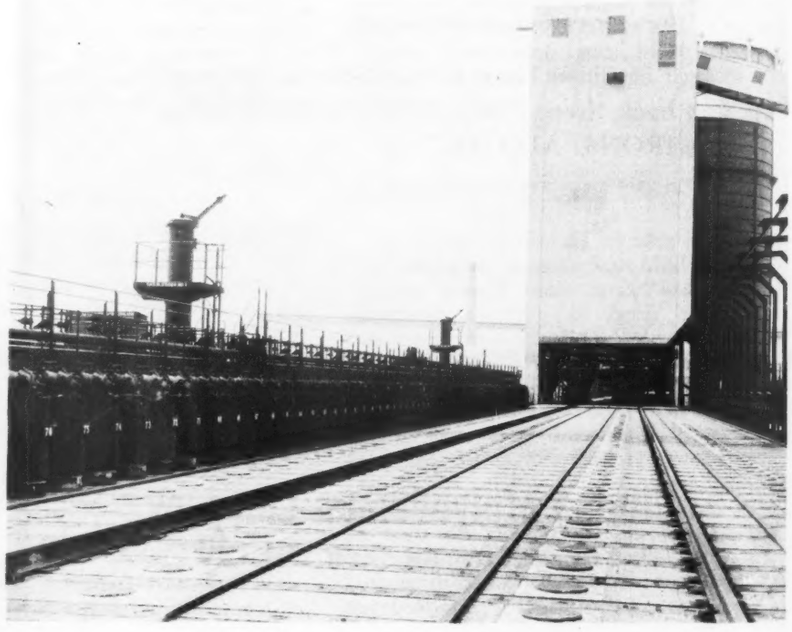
In "Cross-Oven Flue" ovens, gas burns simultaneously in all the flues on one side of the oven, and the waste gas is passed over the oven and through the flues and regenerators on the other side. "Hairpin Flue" type ovens utilize pairs of adjacent flues on each side of the oven chamber. Gas burns in one flue and is passed down through the other.

All the heating flues on one side of a "Four Divided" oven are divided into four sets of six to eight flues each. Gas burning in two sets of flues passes through a horizontal flue along the top of the heating flues to the other two heating-flue-regenerator systems. The use of the horizontal flue in this type of oven has been a subject of great controversy.

When coking is completed, the charge must be pushed from the oven. Each end of an oven is provided with a steel-formed, refractory lined door. Spring action holds the doors in place, forcing a metal sealing edge against a machine-faced jamb to give a gas-tight fit. Hydraulic mechanisms on each side of the battery operate the doors. The pusher ram is inserted into the oven and the charge pushed through into a gondola-like car, called the quenching car. This car is pulled to the quenching station where the hot coke is quenched with water.

A battery of coke ovens is an expensive piece of equipment; it represents a large capital outlay, and in the absence of such stimulus as keen competition in design, the initiation of untried innovations is often slow. Perhaps the biggest advance which could be made at present would be the discovery of some method of arresting the radiation heat loss from the battery surfaces. Little work has thus far been done along this line, except to provide extra thicknesses of firebrick in the battery roof.

This view of a battery top shows standpipes and collecting main.



UNIT HEATING...
its uses and advantages

Where it is used Unit heating is widely used in industrial plants and warehouses, garages, stores and public buildings where the following advantages are important.

Low first cost Unit heaters are so efficient and so compact that their heating capacity is often equivalent to the capacity of cast iron radiation or pipe coils of twice the cost. Additional savings are effected because the system requires a proportionately smaller amount of pipe, fittings and accessories.

Economy of operation Heat is forced down to the working level... not banked uselessly at the ceiling level. Heat is turned on and off merely by throwing a switch either manually or automatically by simple thermostatic controls. The rapid response means that heat is furnished only when and where it is wanted... no heat is wasted.

Heating comfort Unit heaters provide quick heating from a cold start. Desired temperatures are easily maintained within a close range. Heat is uniformly distributed in the working zone by forced air circulation. It is a very flexible system because different or changing heating requirements are easily satisfied by means of different models, a range of capacities, single- or two-speed motors and individual thermostatic controls.

Adaptability to equipment and floor layout The units and the simple piping are overhead where they do not interfere with arrangement of operating machinery or equipment and do not take up valuable floor or wall space. Units are easily relocated at any time to meet changes in plant layout or heating requirements.

Thermolier unit heaters have important construction advantages The design of Thermolier unit heaters is the product of Grinnell Company's ninety-nine years of heating experience. Those responsible for heating like Thermolier's durability, freedom from maintenance troubles and dependable operation. Typical of its construction features is the patented internal cooling leg which permits the use of a plain thermostatic trap, the simplest, least expensive kind of trap. Other features are built-in drainage, continuous rated capacity and provision for expansion of U-tubes.

THERMOLIER
Unit Heaters

99 YEARS — WHENEVER PIPING IS INVOLVED

GRINNELL

Grinnell Company, Inc., Providence, Rhode Island. Branches: Atlanta • Buffalo • Charlotte • Chicago • Cleveland • Cranston • Fresno • Kansas City • Houston Long Beach • Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Sacramento • St. Louis • St. Paul • San Francisco • Seattle • Spokane

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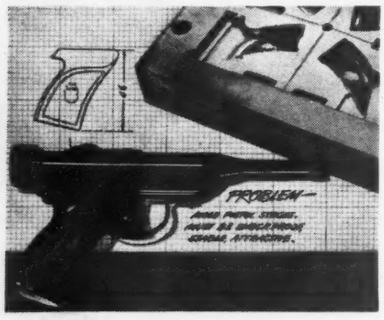
PLASTICS—A MULTIMILLION-DOLLAR INDUSTRY AND STILL GROWING

"Plastics" to most people connotes something modern—something new. And the plastics industry, as it now exists, is still an infant, but a lusty and vigorous one.

How fast it has grown in a short span of years is indicated by these figures, which show the number of plastics molding plants in the United States in the last thirty-nine years:

1910	8 plants
1920	63 plants
1930	172 plants
1940	575 plants
1949	1,160 plants (estimated)



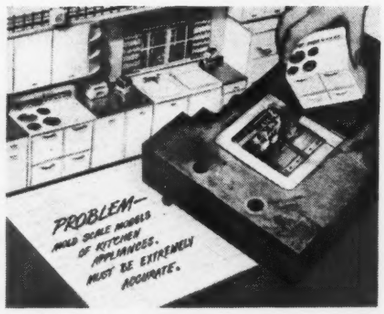
The Ancients Molded Plastics

But the art of casting "plastic" material in molds is an old one. As long ago as King Solomon's time, asphalts and mineral tars were being molded into useful shapes.

These natural molding materials were the only ones available for centuries—until the invention, in 1869, of the first modern synthetic plastic, celluloid. Today the plastics industry makes dozens of synthetic materials with a wide range of molding characteristics.

General Electric entered the plastics business more than fifty years ago by molding carbon rods for arc lamps from clay and lampblack. Later, G. E.'s plastics operations expanded rapidly, when plastics began to be used extensively in electrical insulation.

As General Electric's plastics operations grew, it became practical to offer plastics services to other companies.



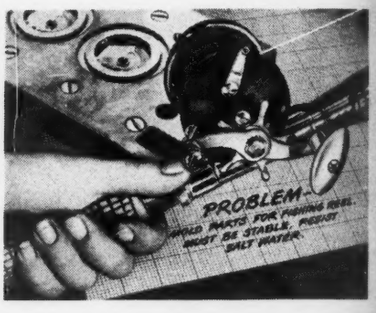
Now General Electric is unique in the industry, being both a manufacturer of plastics molding materials and one of the world's largest plastics molders.

G. E. provides a complete plastics service. It has facilities for producing special types of molding compounds and for designing, engineering, and molding any kind of plastics part or product.

You may breakfast at a dinette table with a surface of G-E Textolite* (a laminated sheet plastics); your toaster may have a base of plastics, molded by G. E.; the breakfast service may be G-E plastics plates and cups in beautiful pastel shades. Your automobile, your refrigerator, your radio, your camera—all are likely to incorporate plastics parts produced by General Electric.

The Scope of G-E Chemical Department's Operations

Molded plastics are just one part of General Electric's Chemical Department's operations. Other products made and sold by the Chemical Department include the amazing new materials of organic-silicon chemistry called silicones, Glyptal* alkyd resins, insulating varnishes, permanent magnets, and plastics



molding compounds. Every month new chemical developments are coming from the G-E research laboratories. And the variety and scope of G-E chemical operations promise to broaden tremendously as this research progresses.

For more information, write Chemical Department, General Electric Company, Pittsfield, Massachusetts.

A message to students of chemistry from

F. W. WARNER

Engineering Manager of the G-E Plastics Division

The rapid growth of the plastics industry in the last ten years offers us some idea of the progress we may expect in plastics within the next decade. For a young man who wants to "grow up" with a rapidly expanding business, the field of plastics seems to offer particularly attractive opportunities.

*REG. U. S. PAT. OFF.

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